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Boston School Series

THE

INFORMATION READERS

NUMBER 2

EVERY-DAY OCCUPATIONS

BY

H. WARREN CLIFFORD, S.D.

BOSTON
BOSTON SCHOOL SUPPLY COMPANY
15 Bromfield Street
1891

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PREFACE.

To-day's school curriculum includes only one subject, Reading, in which the text-books have not kept pace with educational progress. There is no substantial difference between the old American Readers, published sixty years ago, and any series now in use. Yet this fact should not cause surprise. One reading-book must resemble another, if both are merely compilations of extracts chosen for elocutionary purposes. Our present readers are, it is true, more sumptuous specimens of book-making, but children are not sent to school to admire book-covers or to look at pictures.

No selections from Shakspeare and Milton have been culled for the Information Series. The books contain no "pieces to speak." Excerpts on Constitutional Government, the Destiny of Man, and other trivial subjects, must be looked for elsewhere. Nor is the text of the Information Readers a tissue of pretty stories. Means to waste the precious hours of school life can readily be invented, if such waste be desired. No effort has been spared to render information attractive, indeed, but the fundamental aim of the series has not been ignored in a single lesson.

In these books elocution is subordinated to instruction — such instruction as will aid the young learner to understand the life of the world around him. How many school graduates of this year can describe the sources from which food is obtained or can tell how it is marketed? How many appreciate the importance of the railroad as a factor in determining the cost of living in town or country? How many have any knowledge of the processes employed in making cloth? How many know how gas is manufactured? or how steel is produced? or how newspapers are printed?

To the educational public the editors of this series have endeavored to present reading-books the perusal of which will stimulate the perceptive faculties of the pupil, store his mind with practical information, and interest him in various arts and occupations by which hundreds of millions of persons earn their daily bread. Above all, it is hoped that the books will create and foster in the mind of every young reader a just appreciation of the nobility of manual labor.

In the preparation of these volumes several distinguished educators have shown the most friendly interest. The invaluable aid of their counsel and encouragement is gratefully acknowledged.

E. A. B.
H. W. C.
W. G. P.
R. L.

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EVERY-DAY OCCUPATIONS.

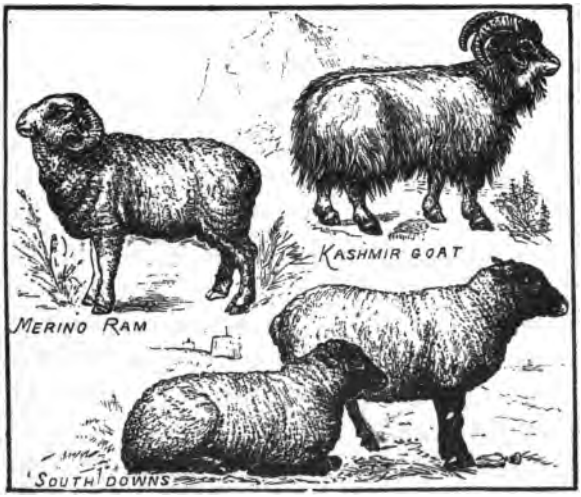
LESSON I.

The First Textile.

THE word "textile" means any fabric wrought in the loom. Hence, whether the threads are spun from products of the animal or the vegetable kingdom; whether they are made of goat's hair, sheep's wool, or camel's hair; whether of flax, hemp, jute or cotton, — the webs from all such materials are textiles. In a few countries garments are made of other substances. Of these perhaps the oddest is paper, which is much used by the Japanese.

In cold countries the furred skins of animals could easily be fashioned into the necessary clothing. Sheep were, in ancient times, raised more for raiment than for food. Prior to the invention of shearing, the locks of wool were torn off by hand and spun from a distaff by women.

Spinning was not in Saxon days an employment of only the humbler classes of female workers, as it became in later times: all ladies, from the king's daughter downwards, engaged in that highly useful occupation. Numerous proofs of this fact are to be found in old English records and elsewhere. So common was the ability to spin wool into yarn, that the term "spinster" was given in law to every unmarried woman.



Wool-giving Animals.

Originally the older inhabitants of Great Britain did not weave their woolen stuffs, but plaited them. A Greek historian of the second century tells us that Boadicea, a Briton queen, wore a robe checkered with colors. This statement leads us to believe that weaving cloth in patterns like Scotch plaids may have been practiced to some extent in England before the first Roman invasion, 55 B.C.

HEMP is a plant of the nettle species, common in the north of Europe. More than two thousand years ago Herodotus, the "Father of History," mentioned this plant as one carefully cultivated in Scythia. The Thracians made from it clothing like linen; and, indeed, only those acquainted with the details of the manufacture of linen can readily distinguish between cloths of hemp and of flax. The Latin name for hemp is *cannabis*, a

Flax and Linen Making.

word from which came our term "canvas," originally meaning any texture woven of hempen thread.

FLAX is indigenous to many countries, but we must turn to ancient Egypt for the earliest specimens of fine flaxen textiles. So famous were these goods that the term applied to them, *byssus*, was the word that the Greeks and Romans used to designate linen. The wise Hebrew monarch, Solomon, praises the "fine linen" of Egypt, and the prophet warns that land that "they shall be confounded who comb and weave fine linen."

We have, moreover, existing proofs of the excellence of Egyptian textile workmanship; numerous mummies have been found swathed in linen fully bearing out the laudations bestowed on the loom-work of the Egypt of remote antiquity. The British Museum has obtained some specimens of this cloth which is so fine that a square inch contains one hundred and forty threads in the warp and sixty-four in the woof. Pieces of linen are to be seen which were woven four thousand years ago.

The term LINEN comes from the Anglo-Saxon word for flax, "lin," and is applied as a general name to cloths made from the fibers of both flax and hemp. Flax is an annual plant attaining a height of about two feet. It is grown extensively in Europe and Hindustan. The flowers are blue. Commercially, flax is valuable, not only for its fibrous tissue, which is obtained from the inner bark, but also for the linseed oil expressed from the seeds. This is a drying oil, and is commonly employed to render paints thin enough to be used.

Till the invention of the Crompton "mule," a machine for spinning cotton, the domestic manufacture of linen was the most widely known industry. Weaving employed large numbers of both sexes. The tremendous impetus given to cotton manufacturing by the inventions of Arkwright, Hargreaves, and Crompton, dealt a heavy blow to the linen manufacture. Formerly the implements used in making linen out of flax were of the simplest construction. For spinning, only the spindle and the distaff, both hand tools, were employed.

Before the fibers of the flax are ready for the spinner, they must be *heckled*, *drawn*, and *roved*. The stalks, having been previously steeped in warm water for some time, are arranged parallel to one another on the bed of the heckling machine, and are pulled against a set of iron teeth, which divide the fibers lengthwise.

They are then passed through the drawing-frame. This draws the fibers into slivers, each one a thousand feet long. In the roving apparatus the slivers are drawn out farther, twisted slightly, and wound on bobbins. Then the wound slivers or "rovings" are spun. The hand-worker could spin only one thread; the most lately patented spinning-machine can spin four hundred threads at the same time. During all the operations the fibers must be kept wet with warm water. The spun yarn may be used as thread for weaving.

As turning flax into yarn consists chiefly in twisting and stretching the fibers, the difference in length between the stalks and the yarn produced from them is astounding. One yard of heckled flax, a pound in weight, is the amount usually allowed to make 9,400 miles of medium yarn. The finest linen thread, used in weaving cambrics and lawns, is spun in Irish factories. To produce the wonderfully delicate thread employed by the makers of Brussels lace, the spinners are obliged to work in dark, wet cellars, in which the spinner must be guided by the sense of touch alone, the filament being too fine to be visible. Twelve hundred dollars a pound has often been paid for the best grade of this yarn.

Many difficulties were met with in trying to adapt the power-loom to the weaving of flax thread. This machine was invented in 1785 by the Rev. Dr. Cartwright, and was a great success in cotton-weaving. But the sudden blow that throws the shuttle across the loom, often broke the linen yarn, which is harder, and therefore more brittle, than cotton yarn. This imperfection was not the only one. It required years of patient experiment to show what alterations should be made in order to fit the machine to weave linen safely and rapidly.

Linen fabrics are numerous in variety and widely different in quality and appearance, ranging from heavy sail-cloth to the finest lawn. Being smoother than cotton, linen does not soil so readily, and it is much stronger, weight for weight. For making several heavy textiles, flax is rivaled by jute, and has to compete with cotton in the production of finer fabrics. The steeping process which flax undergoes before heckling fails to remove all the natural gum in the fiber. If this gum could be taken out by some cheap method, flax could be spun as easily as cotton, the cost of linen would be greatly reduced, and this desirable fabric would come once more into extensive use.

Jute is obtained from the bark of a plant grown principally in the East Indies. It varies in height from five to fourteen feet, and its stalks are about an inch each in diameter. The fiber is separated by retting, that is, by steeping in water. Taken out of the vats, the jute is squeezed between rollers, to soften it more, and is then made into yarn by processes similar to those undergone by flax.

It was not till 1830 that jute made its way into Europe, though it had been used for ages in Hindustan. Coarse bagging was the form in which it was first received; and, as this fabric was strong and exceedingly cheap, its use has become general. Some portions of the products of every country are now transported in this material.

Carpets, carpet linings, mats, tarpaulins, and coarse wrapping-paper also are made of jute. It is unequaled as a substitute for human hair, and when so used, it may truly be called false hair. As jute has a glossy luster, the softer varieties are often mixed with the cheaper grades of silk. Nearly all the parts of the plant can be utilized. Its top is eaten as a kitchen vegetable; the stalks make fences, the seeds oil-cake, the roots paper.

Dundee in Scotland and Calcutta in India are the chief centers of jute-weaving. The United States has several jute factories in successful operation, their total yearly product amounting to over $5,000,000. The increasing use of jute is a benefit to the whole country. Every new industry opens new avenues of employment for the poor. Besides, substituting jute in place of flax, for many fabrics, will leave more flax for the linen manufacture, and will therefore make linen cheaper for us all.

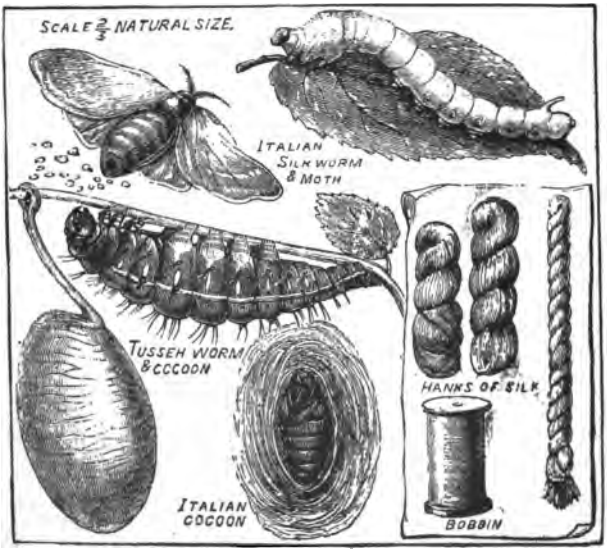
Lesson II.

Throwing Silk.

The silkworm spins from the outside, working inwards, a loose web, growing more and more compact towards the center, till the worm is, at last, quite hidden from view. There it stays, in its silken covering, without food, until the moth appears to moisten the silk and make its way out. Only so many of the worms are allowed to develop into moths as are wanted to lay fertile eggs, or seed, as the eggs are called, for the next year's brood. All the other worms are stifled by heat while in the cocoons.

The silk as spun by the silkworm is almost as fine as cobweb; indeed, cobweb itself has been spun and woven into cloth. Queen Elizabeth had a present more curious than useful made to her, —a pair of stockings knitted from cobweb. A spider, which lives in Farther India, spins a web strong enough to catch small birds.

Silk dresses were worn in China and Japan long before they were known in Europe. The Chinese kept the origin of silk a profound secret. Silk was long thought in Europe to be a plant fiber, like flax and cotton. No one could believe that such a bright, rich, soft substance was the product of a little caterpillar. The secret was found out by some travelers in China, who hid a few of the eggs in a hollow bamboo cane which they brought home. How little idea they must have had that those eggs would prove to be the beginning of the silk-culture, which now spreads from France to Turkey, and finds a livelihood for thousands of families!



Silk Culture.

Think of the many races of people engaged in rearing the worms, in growing the white mulberry, upon whose leaves the silkworms live, and in weaving and dyeing the silk! Think of the myriads of worms that have to be tended in order to produce all the silk we want!

The eating of the soft mulberry leaf, by the tens of thousands of worms in a rearing-house, produces a loud crunching noise. The food of the silkworm, the white mulberry, is, like silk itself, of Chinese origin. In some parts of China the silkworm lives upon this tree in the open air, requiring little or no attention till the cocoons are gathered. The finest tissues, however, are produced under shelter, where constant care is taken to preserve quiet and uniform warmth.

The Chinese claim for their silk industry an antiquity beyond the making of their famous porcelain, a period of at least five thousand years. Long before the Greeks and Romans knew anything of the luxury of silk tissues, the strange Chinese had lost the early power of invention, and went on, age after age, producing their crapes, damasks, and figured satins, which fetched their weight in gold at Rome.

China crape shawls were fit presents for queens, and, until recent years, were thought impossible to surpass. Their elegance has now been reached by French and English skill, and splendid silk fabrics can be purchased by persons of moderate means. China produces nothing new, but displays a remarkable power of imitation. While the Western races take hints from China as starting-points towards higher excellence, that standstill nation makes exact copies of our watches, engines, telescopes, stoves, steamers, and guns, without being thereby inspired to improve.

The chief countries for rearing the worms are Italy, Spain, Greece, and the southern provinces of France. When Mehemet Ali decided to plant millions of trees in Egypt to keep back the desert sand, and in the belief that they would encourage rain on his arid plains, he chose the white mulberry, chiefly in order to aid silk culture. Egypt now produces a good deal of silk. Attempts have been made to rear silkworms here, but our climate seems too cold for them.

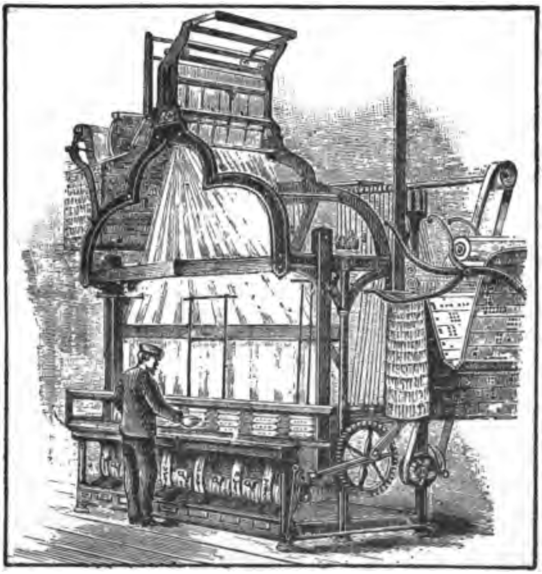
The rearing of the silkworm and the weaving of the silk are difficult arts. Sometimes the two industries are carried on in the same town or district, but in many cases the cocoons are sent from the place of production to the place of manufacture.

Silkworms are liable to a strange disease, from a kind of fungus or mold which spreads through their bodies, and destroys them in such numbers that the whole silk industry of France has been threatened with ruin. To avert this great calamity, new kinds of silkworms of hardier nature were sought for. Six new species have been reared in France since 1860, among them a useful and much larger worm, which feeds on a variety of oak and produces a silky web of considerable value.

Silk-weaving in England owes its first success to the French refugees who settled at Spitalfields in 1688, and who amply repaid their welcome. Many of the weavers retain their French names and habits after two hundred years. France has long been at the head of the silk manufacture. Lyons, the chief center of industry in silkworm rearing, silk weaving and dyeing, maintains its position, though Manchester, England, runs it very close.

Neither fashion nor government aid ever did a hundredth part of the service to silk culture that Jacquard, the inventor of the loom which bears his name, rendered. By a wondrous and complex system of perforated cards, the improved loom produces brocades or figured silks, and its principle has since been applied to weaving figured tissues of all kinds. Jacquard was ill-treated at first, his looms were destroyed, and he was exiled as a reward for his genius; but he lived to be regarded as the father of modern French textile industry. There are now more than twenty thousand improved looms in Lyons.

Next to the Jacquard loom, the discovery of the new coal-tar or aniline dyes has given the strongest impulse to the silk trade. It has put England on a par with France for the brilliancy of colors, in which France had for years taken the lead. These dyes — the brightest ever seen — are a new discovery, surpassing the famous old Tyrian purple, got from certain pink shells. Gas tar, not long ago, was useless and troublesome waste, and would have remained waste, but for the intelligence of gifted chemists, — men that seem, to those who


Jacquard Loom.

get their living by hand-labor, to lead easy and not very useful lives.

Yet these scientists have enlivened the world with beautiful colors; they have given employment to many thousands of workers; they have raised our taste in clothes, since even children have learned to admire the mauves and magentas, the golden yellows, the blues, and the greens, which aniline imparts, alike, to silks and wools, cottons and linens. These dyes make life more cheerful; not only in the innocent pleasure of beautiful dress, but also in the pictures on our walls, the illustrated albums on our tables, and the gayly covered school-books that reward the diligence of our good scholars.

LESSON III.

A Worm Epidemic.

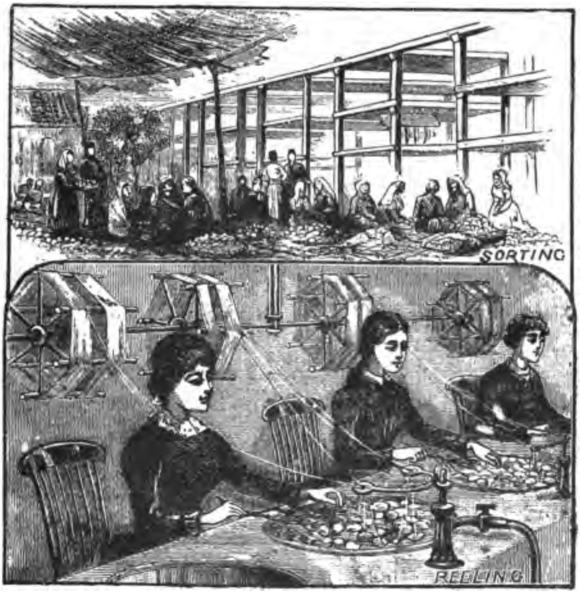
THE gross amount of raw silk produced annually amounts to thousands of tons. When we reflect that the quantity yielded by each cocoon is computed only in grains, we get an idea of the vast number of worms reared in the zone of silk culture round the world, both in the northern and southern hemispheres, for Cape Colony and Australia have entered into the work of supplying raw silk. Twelve tons of cocoons yield on an average one ton of silk yarn.

The silkworm epidemic, which raged before 1865, caused a great national loss to France, and reduced the silk manufacture to a fifth of its former extent. But the value of the raw material did not greatly rise, so wide had become the area of supply. The disease in France gave an impulse to silk culture elsewhere, the former customers of that country learning to weave silk for themselves; while Australia and America grew into dangerous rivals of the Old World, and sent cocoons to England.

For a long while the disease puzzled the most clever men of science. No remedy has even yet been found for the disease itself, which has been arrested for the time being only by extreme precautions. The fungus germs are so minute that nothing but the microscope reveals them to the eye. They are wafted through the air from every worm attacked, and propagate the disease in every worm on which they fall. A heap of dead worms swept out from the rearing-house becomes a hotbed of insect pestilence. The spread of the disease is checked by the instant removal and burning or burial of all infected worms. New healthy silkworm eggs were sought far afield, in

Syria, Persia, Bengal, China, and Japan, — lands out of the range of infection.

The details of the silk manufacture resemble those of wool and cotton, except that silk, not consisting of separate fibers, needs no carding nor combing. Upon the arrival of the cocoons at the mill or factory, they are emptied out of the baskets in which they were brought, and are weighed. Women and girls then sort the cocoons according to size and quality.



Sorting and Reeling Cocoons.

The sorted cocoons are taken to the reeling-room, where they are floated in pans of water, and the dexterous fingers of the reelers catch the loosened thread-ends, attach them to the reels, and wind off the cocoons in continuous hanks. In this state the yarn reaches the throwster, who prepares it for weaving in the common loom for plain silks, and in the Jacquard loom, invented in 1800, for brocades or figured silks.

The chief products of this loom are silks, satins, and velvets, of each of which there are numberless varieties. There are, likewise, many fabrics of silk with other fibers intermixed. Silks are the woven productions, corresponding to the cloths of cotton and wool. Satin has a glossy, smooth nap, which is made by severing the lines of fine meshes formed by every throw to and fro of the shuttle. In velvets these meshes, though still close set, are longer than in satins, and their severance forms a soft pile rather than a nap.

Ribbons are narrow lengths or textures of silk with double selvages, and are used for sashes, bindings, and bows, for the manufacture of which Coventry, England, has long been in high repute. Ribbons may be plainly woven, satin-faced, figured, or brocaded in many different ways. A cheap, useful velvet or velveteen, not possessing the richness of silk, is, by a like process, made of cotton. Plushes are in a similar manner woven of wool, silk, or cotton.

Silk owes much of its value to the readiness with which it will take the brightest dyes without losing any of its own rich luster. French silks have ever stood first for their brilliancy and softness. Until the discovery of the aniline dyes, in 1856, English dyers never approached the French colors. These mineral dye-stuffs have enriched the world with the new mauve and magenta colors, in all their wondrous tints and shades, far excelling the ancient hues and the triumphs of the old dyer's art in France.

LESSON IV.

Combing Fibers.

As the threads of wool and cotton are short and tangled when taken from the bales, the first step is to comb them straight, so that they will lie evenly side by side. The combs or cards are drums of buff leather set closely with steel-wire points, which play one set upon another, taking up and carrying forward the film of cotton or wool lying between, and brushing or combing the fibers while they are flowing along.

"With wiry teeth revolving cards
Release the tangled knots and smooth the raveled fleece;
Next moves the iron band with fingers fine,
Combs the wide card, and forms the eternal line."

Man has been a weaver of woolen cloth from time out of mind. Extensive as is our cotton manufacture, it is scarcely more than a hundred years old. Men used to comb wool by hand; and when this slow mode of working had to give way to machines and steam, many of the poor wool-combers lost their work and wages, and sank into want and misery. Their fate was pitiable; but was it the fault of the machines? The best wool-combers turned their minds and hands to the machines, which they learned to tend. It was the shiftless workers that suffered; those workmen who never tried to meet the change, though they knew it was coming, for it came only by degrees; those combers who never took pains to learn anything else, and thus were fit for nothing else when hand-combing failed.

We can not feel much surprise at the folly of those poor men, when we read about the struggle which the cheap and beautiful cottons from India had in order to get a footing in England, and the still harder struggle that came when calico began to be made there. The Spitalfields silk-weavers, in a fury, mobbed ladies that wore cotton dresses, and the dyers and weavers made such great complaints of the ruin which the "painted calicoes" were bringing upon the woolen manufacture, that Parliament laid a fine of three hundred pounds upon both the seller and the wearer of muslins and chintz brought from the East Indies. A better reason to condemn the first-made English cotton prints would have been, that they were coarse and ugly.

Changes in the modes of labor will happen again. Boys that are now at school may become poor shiftless laborers, unable to adapt themselves to changes of employment. Those boys who take pains, and try to learn all they can, both at school and at home, need never fear those changes. They will foresee, provide for, and benefit by them. Idle and careless boys who neglect their duty, will be incapable workers when men, useless when changes occur, and sufferers from want.

All fibers may be spun into yarn. Ages ago spinning was done by hand alone. But the distaff and spinning-wheel have gone out of use. The spinning of cotton and wool takes place in huge mills, where bobbins without number twist and twirl. These mills, floor above floor, have lines of looms, to weave the cotton longcloths, miles upon miles in length. So excellent are the looms for weaving, that it is cheaper to send the raw material to New England to be woven into fabrics, and then send it back South again as cloth, than to weave it in the country where it grows.

To weave is to make a close network of threads; the warp, of the whole length of the piece of cloth, being set in the loom; the weft is made of the cross-threads, which the shuttle wafts to and fro. Hosiery is not woven, but knotted or knitted, that is, formed into a network of thread. Family knitting-machines, beautifully and carefully adapted from the modern sewing-machines, now complete a stocking or a sock, in one piece, with-

Domestic Spinning.

out a seam or a slip stitch, and make the work of the sock-maker a pleasant home pastime.

There are many fibers, some being obtained from the coats of animals, some from plants, and some even from minerals. Asbestos, a mineral substance, can be woven into cloth, and can not be injured by fire. It has, of late, come into use for fireproof cordage and strong woven coverings, that have to bear much heat. The Romans made a silky cloth from the stringy or fibrous cord by which the *pinna*, a large kind of mussel, anchors itself to the rocks. Wool gives us worsted, baize, blankets, and broadcloths; silk supplies sarcenets, ribbons, and velvets; cotton furnishes calicoes, or longcloths, of endless kinds, fine and coarse, from the muslin of India to strong package; while flax and hemp provide every grade of linen between the finest lawn and sacking.

Man does not produce the wool, silk, cotton, and flax, in the same way in which he produces the cloth. He tends the sheep, rears the silkworm, and tills the fields; but the wool, silk, cotton, and flax are produced *for* us, and not *by* us. With the raw wool or cotton in hand, we set ourselves to weave serges or muslins, which are still wool or cotton, though changed in appearance; but if we want more raw wool, we must wait for it to grow on the sheep's back; if more cotton, we must sow the seed, which is quite different from the cotton itself.

Turn which way we may, we see work to be the lot of man. Every good worker adds to the world's comforts, of which, while want and misery remain, we have too few.

To please the eye and the taste, we color the woven goods. Woolen fabrics are, as a rule, dyed in the wool, because such dyeing lasts better; formerly they were dyed in the piece. Cottons are printed in all manner of designs, and receive the name of cotton-prints. They were at first block-printed, in the same way in which paper-stainers covered their lengths of paper with pretty designs. Cylinders for printing are now engraved by galvanism.

The men who comb the fibers do not make the cards. The leather back of a card is made by the tanner, the teeth are made by the wire-drawer, and the formation of the card itself is a distinct branch of art. Thus each division of labor helps every other division to give us the comfort of good clothes.

Crompton's mule calls, in its construction, as does also Cartwright's power-loom, for the worker in wood and the worker in metals, and the skill and science of the mechanical engineer to guide them. The dyer's and calico-printer's arts take in the whole science of the chemist, and lay all nature under tribute for animal, vegetable, and mineral dyes. From sowing the seed of the cotton-plant through all the stages of the raw substance to the woven cloth, it is only one course of changing labor. The seeming end, too, is but the first of further changes, for the old rag travels to the paper-vat, and comes forth a new and beautiful substance called paper, ready to start on a fresh course of usefulness to mankind.

LESSON V.

Tree-wool.

COTTON is the down or wool attached to the seeds of the cotton-plant. This plant, or tree, is cultivated in various parts of the globe; and as it supplies material for the clothing of all nations, it may well claim to be ranked among the most valuable of nature's productions.

Sea Island cotton is the highest-priced. It grows on the islands near the coast of Georgia, South Carolina, and Florida. Most of the cotton raised in the Southern States is a variety of this species, though owing to differences of climate and soil, the mainland cotton plant is smaller, growing from four to six feet in height, and the wool is shorter in staple — an important difference. Sea Island is three times as valuable as uplands cotton.

Cotton Plantation.

Egyptian cotton of the best grade is also long-fibered. The East Indies, China, and Brazil grow only the short-staple kind, like most of the cotton raised in our Southern States. Calicoes, sheetings, and heavier fabrics such as socks, tablecloths, and bed-spreads, are made from short-fiber cotton.

The long-staple variety is used in making sewing-thread, silk-mixed goods, laces, and muslins.

After the crop is gathered, the shrubs are destroyed and new seed is sowed. Picking begins usually in August, and continues till the occurrence of frost. Before the cotton is ready for market it must be ginned — that is, the seeds must be taken out. This process had to be performed by hand prior to 1793, and cleaning a pound of cotton was regarded as a day's work for an able-bodied slave.

But in that year Eli Whitney, a Massachusetts school-teacher, temporarily residing in Georgia, invented a machine for separating the seeds from the wool. This apparatus, called the saw-gin (from saw-*engine*), has a hopper of wires placed near enough to one another to keep the seeds from passing through; circular saws, attached to a roller underneath, draw the wool down between the wires, leaving the seeds above.

The saw-gin has been of incalculable benefit to humanity; for, by doing the work of millions of hands, it has brought cotton fabrics within the means of even the poorest persons. It has enriched thousands of planters in the South; its money value to the world is too great to be estimated; yet its ingenious inventor died in poverty, having been defrauded out of his rights. As soon as the saw-gin came into general use, the cotton industry increased by leaps and bounds. In 1793 the United States exported 500,000 pounds of cotton; in 1801, 20,000,000 pounds.

Columbus found the cotton-plant growing wild in the West Indies. When Cortez landed on the Mexican coast in 1519, he received garments of cotton from the chiefs of Yucatan, and the ordinary clothing of the Aztecs, the people who inhabited central Mexico, was of the same material.

In 1784 an American merchant in Liverpool had sent to him eight bags of cotton — 1,200 pounds. They were seized by the custom-house officers on the ground that they must be from the West Indies and liable to pay duty; so much cotton, the officers affirmed, could not have been grown here! The United States exported in 1890 over 2,000,000,000 pounds. Under free labor, the culture of this staple is extending in this country. Texas is now the largest cotton-producing State. Our natural advantages, combined with our people's acknowledged enterprise, will enable us to keep the control of the world's cotton market for many years.

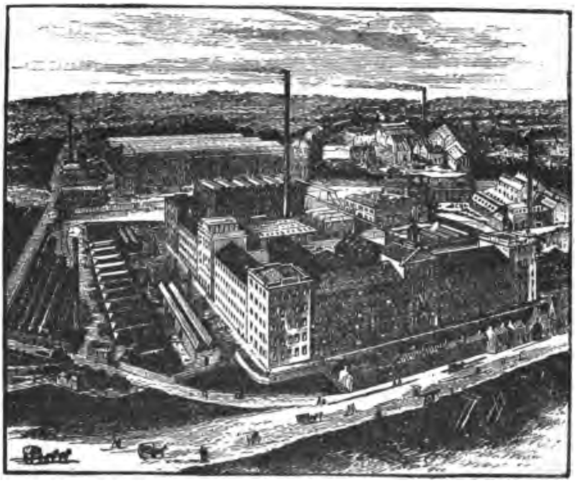
Its down is not the sole valuable product of the plant. The fibers of the stalk are woven into bagging; and pulp can be made from them for the finest kind of writing paper. The seed is remarkably rich in an oil now used for a variety of purposes. It is employed to soften wool, to lubricate machinery, to dress leather; it is used as soap-stock, as a substitute for lard, as a means of cheapening olive and linseed oils, and for various other purposes. The cake, or meal, makes nutritious food for cattle.

What an expanse of knowledge is opened up by the simple word Cotton! We read of thousands of millions of pounds of this tree-wool raised every year, made into tissues, and sent back again to clothe the very people who grew it. We call it the staple industry of the South; we know that millions of our people depend upon it for the comforts of life, and we trace the growth of our wealth and numbers, in a degree, to the labor it sets in motion, and the enterprise which its manufacture inspires.

LESSON VI.

Inside a Factory.

A VISIT to a large cotton-mill in full operation gives us a practical insight into the part which cotton plays in our daily life, — an insight far beyond all the knowledge we can get from books. Massive, and lofty, though plain, are the buildings. Proof after proof of the power of mind over matter strikes the eye — the bales of raw cotton filling a large store-room, the machines which do their tasks as easily and smoothly as if guided by thought and reason, the bales of finished cloths, ready for their mission to mankind.



Cotton Mills.

Baled cotton is full of seed, lumps, and bits of sticks and dirt, and is matted like an Indian's hair. A "blower" cleans the cotton as white as swan-down. Inside the blower there is a beater of steel which turns many times in a second, while a fan below revolves as fast. The beater threshes and the fan winnows the fibers. The dust and refuse fall through chinks to the bottom, while a snowstorm of pure white puffy cotton-wool drives onward.

Thus by steam acting on machinery, as much useful work is done in an hour by a few hands as could be done without the steam and machinery by hundreds of hands in a week. Unless the raw cotton be perfectly clean and free from foreign matters, it can not be made into threads; and until threads are spun, no calico can be forthcoming from the factory.

In this cleaning of the raw cotton is seen, perhaps as plainly as in anything else, the great advance made by the mind of man in this busy century. Here in a single factory we have the natural product of the cotton plant, each fiber of which is almost without strength and is apparently useless. But here also we have machines and steam, both productions of man's intellect, and both man's agents to change snow-like cotton into strong ropes or filmy muslin.

If you unravel a piece of calico you will see that the threads cross one another, twining in and out, over and under, close alongside, in the length and breadth of the cloth. The crossing of the loose and separate threads, so as to combine them into a firm compact sheet of cloth, is called weaving. As clothes to wear have always been one of the first of our needs, weavers of cloth have ever played a large part in the industry of our race. They must have been at work long before men had learned to read and write and to leave records of their labor.

In the earliest picture-writings cut in the stone monuments of Egypt, the weavers are almost as often pictured as the warriors. In China and India, whose histories go back into unknown ages, the weaver's art reached, centuries ago, great skill and perfection. It was all patient hand labor.

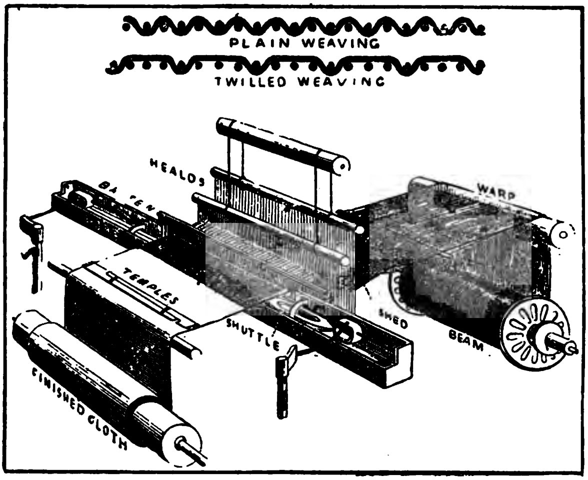
How slow seems the growth of intelligence, since it has been left to this century to change the whole toilsome labor of spinning and weaving, and to make machines produce for us ten thousand-fold the former work of our hands! Machine labor means more abundance, greater comfort, better health, and longer life, to large numbers of people.

A good deal has to be done with the thread before it gets into the loom. As a rule, the twist, to form the *warp* or length-thread of the cloth, is throstle spun, while the *weft*, or breadth-thread, which *wafts* to and fro with the shuttle, is spun by the mule. Women prepare the warp for the loom — a work tedious to do, for much depends upon the warp, and the eye has to keep a careful lookout for a broken thread.

Here is a vast hall, filled with warping-frames not unlike giant clothes-horses, on the bars of which are placed bobbins without number. From all these bobbins the threads are drawn, to a roller, just the width of the cloth to be woven. They pass on their way through a machine, which keeps them their exact distances apart, and round the roller they wind — calico without the cross thread or weft. The straight lines of thread remind us of our youthful "cratch cradle," here raised to the height of a game sublime. The warp stops once more on the road to the loom. It has to be unrolled and "dressed," or passed through a hot bath of flour and water, to strengthen it. Coming up wet from its dive, it travels quickly, over and under a range of heated metal rollers, and winds up once more, now dry and stiff.

The final stoppage is at the power-loom, where the roll of warp must be fixed in place, and the threads run through eyelet-holes, a line of which stretches across the frame. Girls feed the eyelet-holes with the thread, and on the opposite side of the frame the quick fingers of other girls hook the threads through, two at a time, with a sort of double crochet-hook.

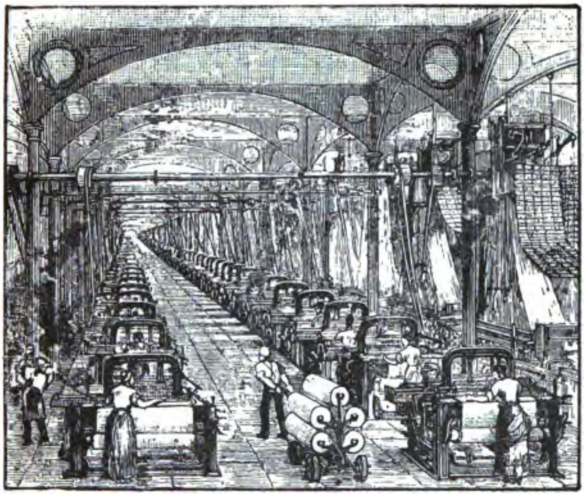
The action of the loom upon the warp is to raise one set of threads, and to lower the other set, so as to divide the warp into two sheets of thread. Weaving is trying labor, for every separate thread must be seen to, so that all shall rise and fall without mistake, and at the same time travel on towards the shuttle. Labor is saved by cutting off the remnant of an old warp, leaving the ends in the eyelets, and piecing those ends on to a new warp. Quickly as this work can be done, compared with threading the eyelet-holes, it can be done only a few times, for the eyelets are soon used up, and the making of new ones is a distinct branch of industry which employs many hands.



Principle of Power-loom.

Go in whatever part of a cotton factory you will, there is the same length of shafting down the center; the same movement of many machines; the same vastness, the same hurry and noise.

Covering the floor of the weaving-room are the looms, not ancient hand-looms each one the size of a tent bedstead, but power-looms, as large and heavy as steam printing-presses. In one immense room there may be fifteen hundred looms, each lighted up by its own gas-jet, and each set in motion by the same all-powerful shaft.



Power-looms.

Weaving is, we notice, chiefly in the hands of women and girls. Watch that roll of woven cloth slowly lengthen and lengthen as the shuttle flies to and fro, with the blows it gets on either side! Self-acting arms fling it backwards and forwards, as if in spite, and do not cease till the cob is wound out. At each throw of the weft-cob in the shuttle, the cloth is batted with a stroke from the loom; the eyelet string-frames draw the half-warps across each other's threads, and make a new roadway for the shuttle.

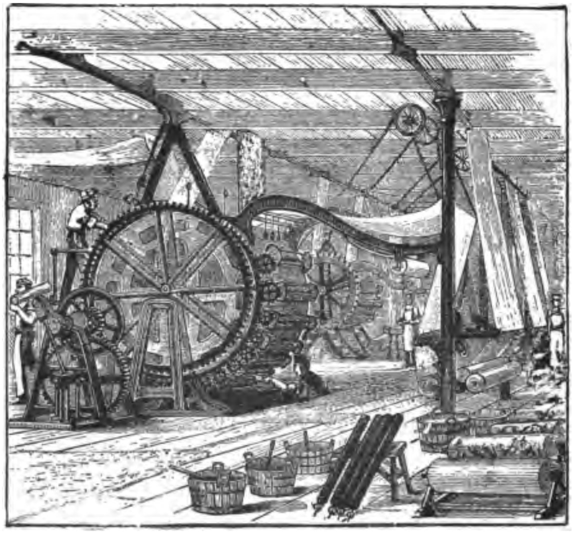
We leave the Hall of a Thousand Lights to pay our homage to the Father of all the noise and motion. We find him alone in all his grandeur, hidden from vulgar eyes, like an Eastern monarch, with his grand vizier, the engineer-in-chief, to whom alone he cares to speak.

Those massive see-saw beams, the heavy tackle, that ponderous iron fly-wheel, twenty-four feet across, on a spindle of solid iron, three yards in girth, all move with such regularity and ease, that they look light, as they perform their work. From the roof hang weighty iron hooks, for use when any part of the engine needs to be put in its place. How the heavy cranks and fly-wheel were ever got in position is a puzzle. Yet a simple square box, with a handle protruding, the motive force cold water, lifted, and would lift again, those terrific weights.

Cotton affords a striking instance of the relation between human labor and the enterprise which springs from knowledge. He who would know everything about cotton, must, like Lord Bacon, take all knowledge for his province. Think of the increasing growth of cotton in various lands; of this staple's influence upon the welfare of mankind; of its effect upon our habits, opinions, laws, and rates of wages; of the shameful system of slavery, which kept millions of our own fellow-creatures in chains, and led to a fearful civil war; of the vast amount of cotton raised and the commerce it creates, with the wonders of every stage of its manufacture, and the growth it has caused in our exports!

Turn to cotton-printing. Think of the arts, sciences, and financial ability bound up in this one branch of the industry. There are the madder and other vegetable dyes, the brilliant coal dyes, and the metallic mixtures, to make the dyes fast; all the elements which the chemist controls must be studied in turn, — their produce, collection, preparation, blending, use and effects. The designer's art searches through all nature for patterns. The engraver's art leads us to reflect upon his skill, the tools he uses, and the copper cylinders he draws upon for printing.

Think again of the mills as buildings; factories inland, and warehouses at the ports; busy beehives of useful labor where there are no drones. Think of the hands and brains set working in the art of their construction, with their tall chimney shafts, the building of which is an art in itself.



Calico Printing.

From coal to steam and the machines it endows with power; from steam to humble inventors, rising to riches and fame; from the credit, founded upon good faith, which sustains the growth of our vast wealth; from the factory system, to the mercy bestowed by the law upon child workers, to secure them from stunted body and mind, — there is no end to the suggestive lessons which cotton reads to us. Cotton enters so largely into various needs of modern life, that, to dwell upon their details would take our minds from the busy works of our New England towns to every city in the Union.

Lesson VII.

Hands and Machines.

Twenty centuries before Europe thought of manufacturing cotton, India had in every-day use a system of hand spinning, dyeing, and weaving, which during that vast interval received no improvement. The Hindus, the ruling race of India, were highly civilized at a time when Europeans were in the lowest depths of barbarism. Yet the former people have made no approach to the ingenuity shown in the textile machinery of modern times, nor have they bettered or extended the cultivation of the raw cotton.

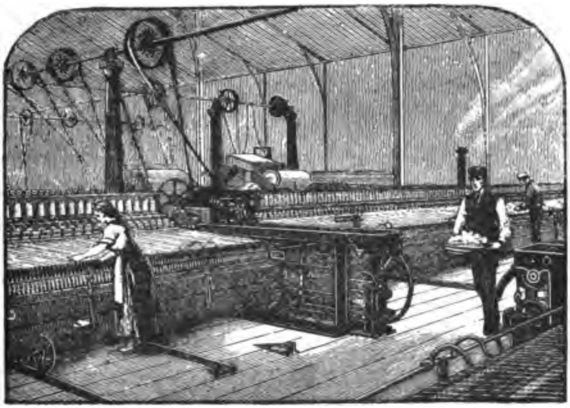
Until about the beginning of the eleventh century cotton cloth was rare and precious in Hindustan's rival in antiquity, China. Historical records of the latter country mention, as a very remarkable circumstance, that the Emperor Ou-ti, whose reign began in 502, owned a cotton robe. To-day the poorest Chinaman can out-rival such magnificence. The cotton tree was introduced into China by the conquering Mongol Tartars in the year 1280, and afterwards the government offered every encouragement to the cultivation and manufacture of cotton. Yet even to-day China imports immense quantities of various cotton fabrics.

The implements which the Hindu craftsman uses in the different processes of cotton working, from the cleaning of the down to its conversion into the finest muslin, may be bought for two or three dollars, and are so rude and simple in construction that they must be inventions of a very early period. The yarn is spun on the distaff. Still it is singular that with the help of the best machinery we find it difficult to equal in fineness and strength the yarn made by the Hindu hand-spinner.

The loom consists of a few reeds, which the spinner carries with him from place to place, and puts up under the shade of some tree. He digs a trench in the ground deep enough to contain the lower half of the instrument, and fastens the remainder to some convenient branch overhead. The warp is laid out on the ground the whole length of the piece of cloth. Yet Hindu craftsmen, working with such clumsy tools, produce those famous Dacca muslins, which are so fine as to be almost worthy of their poetical description —

"Webs of woven wind."

The first piece of British-made calico — that is, a fabric all cotton — was produced in 1783. Prior to that date; cotton yarn had been used for weft only, the warp being supplied by flax or wool. Crompton's spinning "mule," patented in 1779, made the cotton industry one of national importance. Watt's steam-engine was used in the manufacture of cotton for the first time in 1785. In that year the Rev. Dr. Cartwright invented the power-loom. Bell had previously thought out the process of cylinder printing, enabling two men to do the



Spinning-Mules.

work of two hundred. In the same year (1783) acids were first employed in bleaching, shortening the operation from several months to a few days.

Hargreaves's spinning-machine, the first successful one, had eight spindles. A spinning-mule of to-day may contain 1,200. At full speed each spindle makes 10,000 revolutions a minute. Half a century ago the rate of the best loom was about a pick (a throw of the shuttle) a second. Light calico looms now in use make 400 picks a minute.

The steam-engine, the spinning-mule, the power-loom, the roller-printer, an abundance of coal and iron — all combined to give England a monopoly of the cotton manufacture for half a century. The enormous wealth thus acquired enabled her to spend vast sums, year after year, in aid of other countries, during the gigantic struggle against Napoleon. England was the only great power in Europe not bankrupted when, in 1815, Waterloo closed twenty years of war.

Riches may, however, be gained at too great a cost. A committee appointed by Parliament found that British cotton factories were practically slave prisons. The owners wanted the cheapest labor; and, the machines needing only tenders, employment was offered to children. But parents had a strong dislike to sending their sons and daughters to work in the cotton-mills. How, then, were procured the little toilers out of whose pitiable labor rich men grew richer? As you are, fortunately for yourself, an American child, you would never guess that those little drudges came from the poorhouses.

Overseers of the poor sent thousands of children to the Lancashire factory district. They were usually kept in dark cellars till they could be apprenticed to mill-owners. These would come and examine the size and strength of the helpless young creatures, just as buyers used to examine slaves in the American slave markets. The treatment of these unfortunate children was most inhuman. Their hours of labor were limited only by exhaustion after repeated punishments had been applied to compel the little victims to continue working.

Children toiled sixteen hours a day in most factories. Even Sunday was not a day of rest, it being used as a convenient time to clean the machinery. In foul air, amid the dangers of a thousand wheels and belts, little hands and little feet were kept in ceaseless activity. Blows and kicks from merciless foremen drove wearied children to labor at exhausting tasks.

Some of these wretched young white slaves tried to run away. Generally they were caught, and then they had irons riveted on each ankle — irons with long links fastened to a belt around the waist. They were obliged to work in these chains. It was not till 1840 that complete relief was obtained from this horrible system of British cotton-mill slavery. How thankful should be children that have comfortable homes, and no work except school work!

LESSON VIII.

The Sheep's Gift.

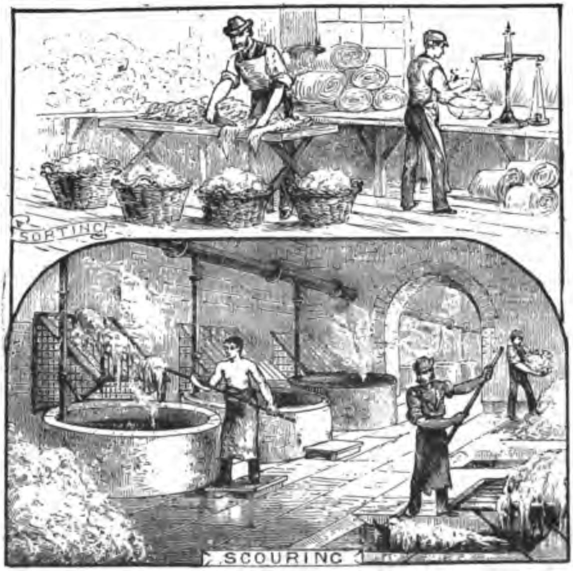
WOOL is the most important of the animal fibers. Its soft curly structure distinguishes it from hair. Sheep are the most numerous producers of wool, but are not by any means the only creatures yielding this substance. The covering of the alpaca, and of the llama, the mohair of the angora goat, and the soft woolly hair of the camel are all wools of much industrial importance, while the most costly wool in the world is obtained from the cashmere goat of the Himalayan Mountains.

The ease with which wool can be made into thread must have very early suggested the use of this fiber as a textile for clothing. Among the arts of civilized life which Great Britain owes to ancient Rome, not the least important one is the manufacture of wool into cloth. The sheep was, it is true, a domestic animal in England long before the Roman invasion, and doubtless the Britons, like other uncivilized peoples, wore sheepskin garments. But woolen factories were established first by the Romans who used them to make cloth for the occupying legions. The value of the manufacture was, however, soon perceived by the natives.

During the Middle Ages, English wool was, on account of its excellence, in great demand in European centers of wool manufacturing. Flemish weavers, driven from their homes by political troubles, settled in England, and taught the English how to weave woolens of good quality.

Examined under the microscope, wool is seen to possess a saw-like structure, all the teeth pointing in the same direction. A lock of wool drawn (between the finger and the thumb) from the root end outwards, slips quite smoothly; if drawn in the opposite direction, the fiber feels rough, and offers a distinct resistance. Under the influence of moisture and pressure tangled masses of wool mat together by means of the interlacing of the serrated parts of the fibers. In like manner woolen cloth thickens and shrinks in washing.

Wool comes to us mainly from Australia, the Argentine Republic, and Cape Colony. Dealers divide wool into *carding* wools, in which felting properties are desirable, *combing* wools, requiring length of staple, and *carpet* and *knitting* wools, which are inferior in quality to the other two. What kind of sheep furnish the highest grade of wool? The merinos of Saxony and Silesia, Germany.



Wool-Washing.

The quantity of wool which a sheep yields at one clipping is called a fleece. A skillful shearer will clip the fleece from a sheep in one unbroken sheet, retaining the position of each lock of wool as well as if the animal had been flayed. A fleece of this kind is easily sorted into its different grades. The best grade comes from the side.

At the factory the first process that the wool undergoes, preparatory to being made into cloth, is a washing by machines. Placed in an immense bowl containing a strong solution of soap, the wool is allowed to soak for a short time, then is tossed about, and passed into a second bowl holding a weaker soap solution. Drying is the next operation, and is done partly by squeezing the wool between heavy rollers. Afterwards it is placed in a large drum with meshed sides of heavy wire. This drum is whizzed around so fast that it seems stationary. The water from the wool flies out through the sides in fine spray. In some factories the rolled wool is dried over wire netting, underneath which is a floor of steam-heated pipes.

Having been washed, the wool has lost its natural grease, and is somewhat wiry and harsh to the touch. Hence, it becomes necessary, before carding it, to render it supple, soft and elastic. Oil is, therefore, sprayed over the wool which, spread out in very thin sheets, is carried by an endless band of canvas or cloth under the spraying instrument.

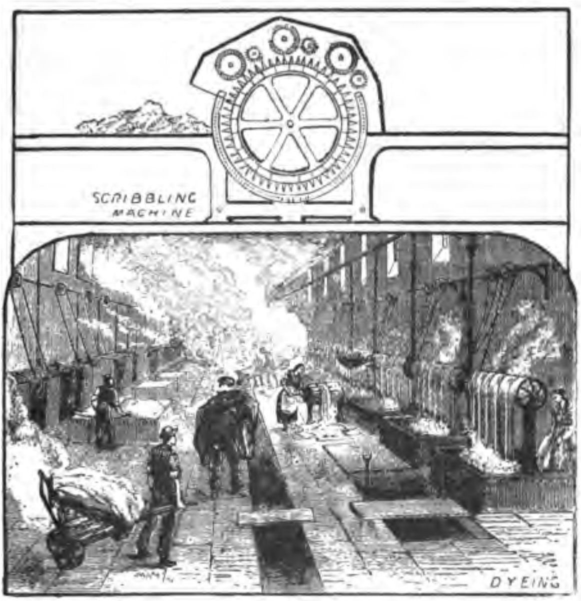
LESSON IX.

Cloth.

THE apparently spotless and speckless fleece is not such to the keen eyes of the wool-worker. It must go through an engine that tears apart the fibers of wool, and sifts from them the last grain of dirt and refuse. An odd-looking boy with muffled mouth, fills with wool the maw of a big box-like machine. Its working powers never cease, but go on with a deafening rumble. While we look, the wool pours and puffs from the front in large flakes, which soon lie thick upon the floor.

We can tell now why the worker in charge muffles his mouth; minus a muffle he would breathe little but dust. Peer inside, and you will see a drum, set with spikes, working in and out between other spikes fixed in the box-work around. A fearful-looking engine is "Old Scratch" of which the hands are very much afraid. Such an engine is also found in every shoddy-mill, where it rends cast-off woolen rags into fibers again, ready to work up into the cheap cloths which have, in recent years, more than doubled our stores of clothing, and added to the health and comfort of the poor.

If the cloth is to be wool-dyed, we lose sight of the clean wool, until it returns colored and ready for the carder, spinner, and weaver. We pace an avenue flanked by "scribbling" and "carding" engines on one side, and by other curious kinds of engines on the other. Scribblers are much larger than carders, their work being in fact a first carding. Both machines consist of rollers, faced with felt, and planted with short wires like the bristles of a scrubbing-brush.



Dyeing and Scribbling Machinery.

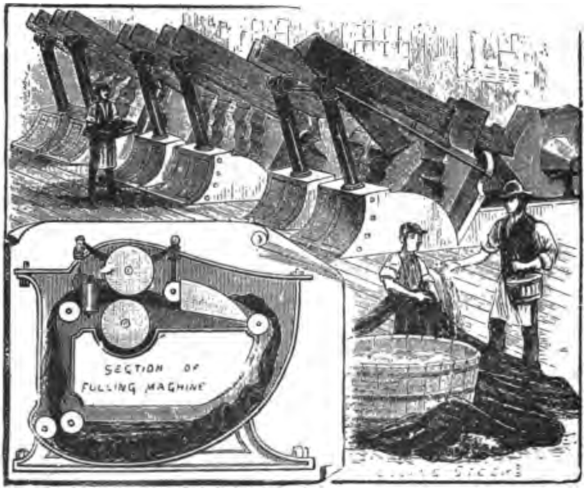
One roller takes up the dyed wool, but in the course of its first turn meets a second roller, which moves the opposite way, and picks off every bit of the wool. A third roller cleans the second, and a fourth the third. By the time the wool gets to the end of the frame, it has passed over a long series of rollers, has been brushed and combed, and each fiber lies even with the rest. Carding repeats the scribbling with a small machine, which has each of its wiry surfaces formed of half a dozen strips.

Long snaky bands of wool are, therefore, given off instead of broad laps, and, as fast as they surrender themselves, a girl joins them to other bands, carded before, and they travel on to other parts of the machine. Hundreds of bobbins wheel up to meet the evened wool. So on through several machines, the slivers stretch and lengthen, twine and twist, unite and lessen; wind on to "spools," large bobbins, and unwind on to bobbins proper, and finally reach the doubling-machine.

The machines know exactly when to stop, when to go back, stretching and twisting the wool, as it spins merrily round the dancing spindles. The wool came from carding as thick as one's arm. Now the carded bands have become slightly twisted, spongy, worsted threads, scarcely as thick as crow-quills or small straws. Thus these strange self-acting frames keep on, backwards and forwards, twisting and twirling, till the bobbins are wound full, and then others take their place.

A power-loom at work is a grand sight. The unseen motive force that sets it at work impresses one with the sense of life, even as a savage or a child fancies the acting works of a watch to be alive. There is method in the complex movements; method guided by mind, and mind seems to be in the engine. When the looms are numbered by scores, and their clatterings blend in one deadening dull roar, and the mass of gearing bewilders the eye with its play, admiration grows to wonder and awe. The looms are tended by women, who add by their aspect to the strangeness of the scene. Dressed in uniform, a blue cotton dress tied round the neck, they look like big girls all of an age. A little nearer we see that many of them are elderly women. So much of the work appears to be done by women, that we are led to doubt whether men are wanted at all in the factory.

Broadcloth, this woven stuff is, indeed; but if you think it ready for the tailor, you make a great mistake. Common, rough, coarse serge it seems now, and it must pass through many more hands before it is finished as superfine double broadcloth, fit for use. The breadth has to be reduced, and the open threads must be made to assume a close grain. This is the problem : To diminish a piece of cloth three yards wide, to half the width and two-thirds of the length, without cutting away or wasting the substance. The fullers solve this problem by shrinking.



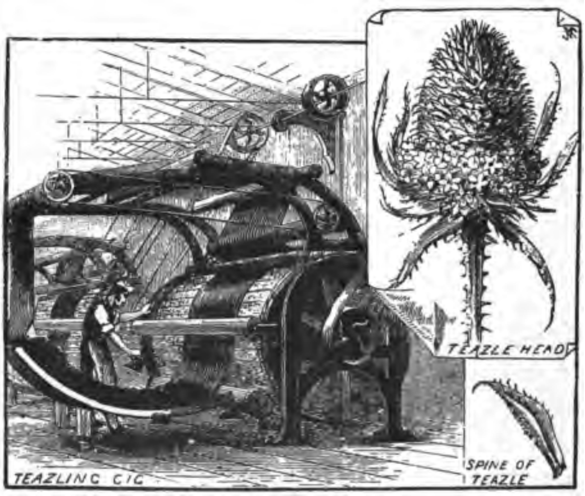
Fulling the Cloth.

The good old plan was to pound the cloth with bulky tilt-hammers made of wood. By modern methods, the process is far less clumsy. The cloth is sewn into an endless piece, and wends its way upward, getting squeezed at the top between two rollers, whence it descends into a bath of water and fullers' earth, a soapy compound. Soaked over and over again, the cloth is, after each soaking, relieved of the liquid by pressure between the rollers. The milling ended, we see that the serge has lost its coarseness, and has become fine-grained cloth. If extra thickness and strength are sought, the fulling is renewed, and the "double-milled" broadcloth, so pleasing to the eye, is the result. The process of fulling is easy to understand, but the reason why the serge should thicken and grow fine-grained, will be more clearly seen in a future lesson on felted cloths.

The fabric at length assumes a texture smooth to the hand, and becomes elastic, free from wrinkles, and uniform in appearance on both face and back. It is once more returned to the washing-machine, wherein every remaining impurity is removed, and it issues ready for the finishing touches, which will make it broadcloth suitable for coatings.

There are two kinds of teasels, the wild ones and the cultivated. In the cultivated teasel, the hooks are close set and of very strong texture. The head of the teasel is covered with awns, curving back towards the stem.

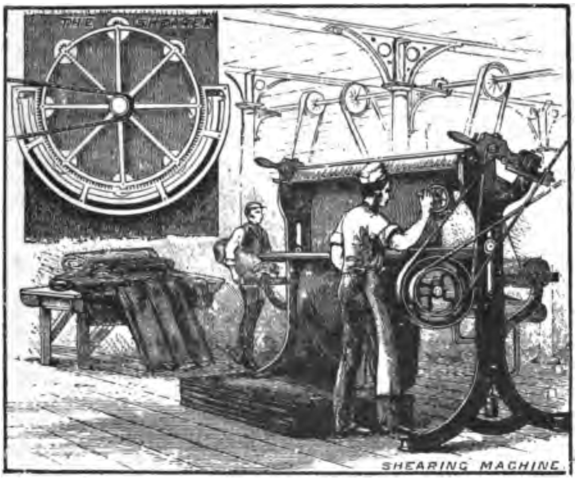
While teaseling the cloth, — that is, raising a nap on it, — the awns, or thorns, becoming wet, soften and straighten out, but in drying they curve back into their original shape. The cloth manufacturers stand ready to reward richly any person inventing a teaseling-machine whose metal teeth will be as firm yet elastic as these vegetal awns.



Teaseling the Cloth.

The cloth passes from a lower cylinder quickly over a middle one, covered with teasels, to a cylinder above, while small jets of water play upon the cloth to keep a moist surface for the awns to act upon.

The teasels are renewed nearly every day, as they soon get clogged with flock. Until recently it was the work of children to pick them clean of the fluff which clings to them, but such labor is much more quickly done now by a fast revolving cylindrical brush. The number of teasels consumed in a year is immense. Wagon-loads of them are constant callers at the gates of every woolen mill.



Shearing.

Looking at the cloth after teaseling, we see how the fibers have been hooked out and laid straight, forming a beaver cloth. Their ends, however, are not as yet of equal length. After leaving the gig, the cloth passes through the cutting-machine, or shearing-engine, which shears the nap off close, leaving an even face to the cloth. The shears work on the simple principle of our lawn-mowers. The cutting part consists of a roller, round which wind spiral sharp edges which, while revolving, meet, in turn, a fixed straight blade, and act as a series of scissors. The cloth, hooked across its breadth with half a dozen hooks, passes under the cutting-blade of this odd barber, and comes out as smooth as a fresh-shaved chin. For extra superfine goods the cloth is several times teaseled and mowed. Great presses take the folded fabric, and give it a thorough pressing for a whole day, to take out the creases, to bring the bulk down, and to prepare the cloth for packing.

The woolen cloth-makers furnish, in the history of their craft, many examples to inspire us to industry; examples of heroes in the factory, of triumphs over difficulties, of success in the face of failure, and of skill which has enabled them to outstrip foreign rivals. Since wool-combers had to give way to carding-machines — and, still more lately, since water-power has been superseded by steam, the course of industry has been changing to better and cheaper production. Advances promise to be as much greater in the next age as, in this age, they are greater than they were in the last. Improvements are being made in every stage of cloth manufacturing, from the sorting of the wool to the packing of the cloth in bales.

One feat of inventors has been to combine, in one engine, the former work of several engines, to the saving of time, labor, and cost, so that the old terms of scribblers, slubbers and billies have been nearly forgotten. In fulling, a composition of soap and soda takes the place of fullers' earth, this last detergent being added only when the cloths are very difficult to cleanse. The whole process, too, is gone through with in a compact chamber, where the after cleansing of the cloths is likewise completed. The method is so much altered, that the name of fulling has dropped almost out of use, and "braying" is the term employed. Gains in the spinning-mule and in the power-loom consist more in many small devices to make their working more effective than in any changes in their ground principles of construction.

Lesson X.

Changes and Triumphs.

While these changes have been going on, how have the poor wool-workers fared? This question brings us again to the subject called the morals of machinery. We notice that improvement has been constant, and is still going on. All the world reaps the benefit of advances. Progress in well-being is a law of our nature. Whether the workers have lost or gained by change, no one wishes to go back to the old state of things. Many of the wool-workers sank into poverty, not because better modes of working were brought into operation, but because they could not adapt themselves to the new methods.

Changes in industry, which are for the good of all, ought to encourage, not to discourage, every young artisan ; for they mean, that, if he gives his mind to his work, and uses his industrial gifts and talents well, he will be the first to benefit by every invention that makes his skill more productive.

A complaint that workingmen sometimes make is that employers adopt new inventions only for their own profit, careless of the loss to those whom they employ. Facts do not bear out this complaint. Some employers flourish and some fail. Some employers dislike and oppose alterations. Then other producers outstrip them. There are old cloth mills, once among the largest in the trade, keeping to old customs, and now reduced to very few hands. There are new mills, large and well-equipped, owned by intelligent men, who, a few years ago, were working hands.

Every year some of the ablest workers leave the ranks of labor, to become foremen, managers, and employers; while wealthy owners retire, and incapable ones fail, and make room for others, gifted with the knowledge, skill, and intelligence, which make men successful in life. You may hear incompetent men allege that their loss is due to their bad luck. They will say that the deserving and successful were born to good luck. "Better be born lucky than rich." Do not believe such persons. There is no path open to success, except through merit.

> "'Tis not in mortals to command success,
> But we'll do more — deserve it."

It is not in nature *always* to command success; but it *is* a law of nature, for merit, in the long run, to win, where demerit fails.

Animals, plants, and even minerals, have all helped to cover our bodies and keep us warm. We glean from the field of nature the things to make the clothes we wear, but by our intelligence we have added greatly to the number of the substances we use and the amount we produce. The history of cloth is full of lessons to prove that industry has gained grander victories than war.

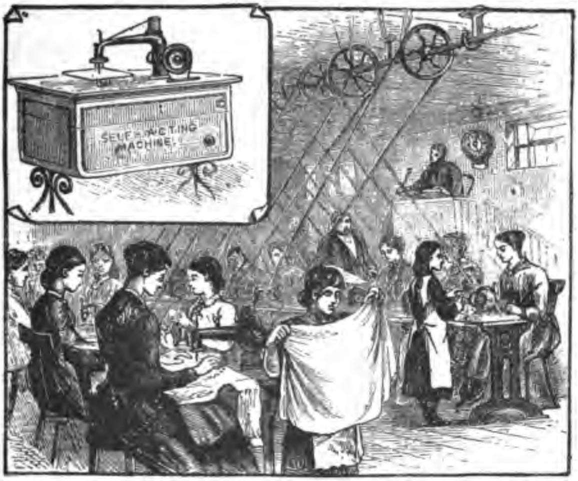
Needles are as ancient as clothing, and almost as varied. They have been made of thorns, wood, metal, fish-spines, bone, ivory, and steel. Girls, in all ages, have been taught to ply the needle, and men, whom we call tailors, have been taught to cut, sew, and fit, as their trade. Children give their mothers and sisters plenty of work in making and mending, though good boys spare them much trouble by keeping their clothes clean and untorn.

When there were but few books, and even kings could not read, and people did not travel, women filled up their time at home, in spinning and sewing. Many fine old pieces of needlework, done by ladies, while their husbands, brothers, and sons were gone to the wars, remain as wonderful works of beauty and skill.

As population increased, hand-sewers could not do fast enough the work of supplying the clothes wanted, though needlewomen, by the thousand, were working in dreary garrets, at the lowest wages. The heart of England was moved to pity by the cry of anguish in Hood's "Song of the Shirt." Men and women were touched deeply by the truth told to them : —

> "It is not linen you're wearing out,
> But human creatures' lives."

The poor needlewomen were in a pitiable condition indeed, till intelligence came to their aid. A Nottingham lacemaker made a sewing-machine, not very useful at first, but busy brains in America soon made it valuable. As if with the touch of a fairy wand, the sorrowful sisters of the needle became smart and well-paid machine-workers, receiving a fair day's wages for a fair day's work. At least a dozen trades turned their round of dreary trial into light and pleasant labor. The saddler, tailor, and shoemaker have as great cause as the poor seamstress to be thankful to the genius of the American mechanic, Elias Howe.


SELF-ACTING MACHINE.

Sewing-Machines.

Here we should think there was a case where everybody would bless a new machine; but mobs turned out to jeer at mechanical science ; to smash windows, and to wreck the machines, which, in their blind rage, they thought would destroy their means of living.

The sewing-machine is another beautiful instance of the part which the intellect plays in labor. At first a broken stitch let all the other stitches run loose. Intelligence pointed out the way to fasten every stitch, and the lock-stitch machine was the result. Again, the working of the machine was so noisy, that landlords often made their tenants promise not to have one, for fear of annoyance to the neighbors. Brains planned a machine to work almost in silence. The last and longest trial was the handturning or the footwork required to operate the machine. This labor was almost as tiring as sewing by hand. Intelligence applied steam power to the machines. It can drive the needle a thousand stitches a minute, and sew any kind of work, from saddles to shirts.

In seeking after new inventions man's mind never tires. If with the sewing-machine the seamstress can make ten shirts in the time she could formerly make only one, why not make ten at once? The cloth-cutting machine answers by cutting to shape ten, twenty, fifty layers, of any kind of cloth, with a rapidity and an exactness which the tailor's shears cannot equal.

Intelligence has done more than add to our comfort and save us from toil. Intelligence leaves to the hand fewer and fewer mean tasks. Machines save us from grime, give the mind free play for thought, and afford us more chance to improve. They make work noble, and enforce the truth in the poet's lines: —

> "Honor and shame from no condition rise;
> Act well your part; there all the honor lies."

Lesson XI.

Felting.

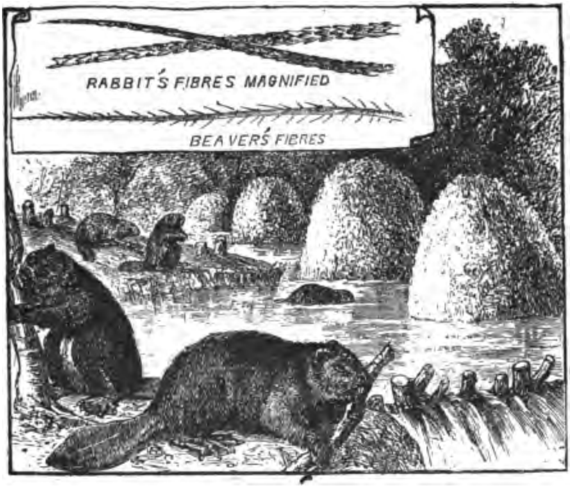
We are apt to speak of all living creatures except ourselves, as the lower animals; yet, at first sight, we seem to be worse off than they are for the means of warmth. The cat is always dressed; the sheep, warm in its thick coat of wool, can stop out all night in the field, and not suffer from cold; the Polar bear has a covering of hair to protect it from the northern icy winds; even the humble caterpillar can spin a cocoon of silk to nestle in, while changing into a moth.

Man has, however, a power which no other living creature possesses, — the power of reason. The cat has only its fur to keep it warm, the sheep its wool, the bear its hair, the bird its feathers; man has the gift of reason, which opens the wide realms of nature to him, and enables him to choose what he pleases for clothing. He takes the down from the cotton-pod, the fibers from flax and hemp, the wool from the sheep, the fur from the seal, the silk from the moth, and makes himself apparel of several materials.

The covering of animals accords with the climates they live in. In the Frigid Zone it is soft, thick, and warm, like the seal's coat. In the Temperate Zone it is heavy and close in the winter; loose, coarse, and shaggy as summer comes on, when, if not sheared, it sheds of itself. In the Torrid Zone it is thin and scanty, like the covering of the camel.

When an animal's coating is loose and coarse, we call it hair, which is the name given to the covering of the horse, the goat, and the dog; when it is matted and thick, we call it wool, the fleece of the sheep; when soft and fine, we call it fur, the coating of the cat, the rabbit, and the beaver.

Furs have ever been the richest and warmest of the clothing we wear. They impart a look of comfort and luxury to the wearer. We flay the animals which provide the fur, dress the skins entire, and make the leather, by dressing, as beautiful as the fur upon it. Were we to shear the fur, to card, spin, and weave the short silky fibers, as we do cotton and wool, we should not get a fabric to compare with that which the fur animals give us ready-made. Where the fur is shorn, as is hare, rabbit, and beaver fur, it used to be felted by means of a bowstring. Felt differs from woven cloth, because felt fibers merely mat together, and do not form a network of threads.



Beavers.

The principle of felting was not understood until the microscope revealed the shape of animal fibers. By magnifying the wool or fur, the central stem was seen to have a number of minute teeth projecting from its surface, and sloping towards the point of the fiber. It is these teeth that hold a cat's fur together in a smooth coat when the fur is stroked the right way. When sheared from the skin, the fibers even easily in one direction. When rubbed and pressed, and caused by warmth and moisture to curl, they felt, or twist round one another, and the teeth, interlacing tightly, form a strong cloth.

The old process of bowing was continued up to 1843. Since then the work of the felter has been done by the forming-machine. The old bow was a stick of wood, two yards long, like a fiddle-bow, with a single catgut string. By means of this simple tool, when its use was learned, animal fibers could be felted, by a weary process, and a felter could produce no more cloth in a day than with the forming-machine he can produce in half an hour. Felted druggets and cloths are composed of wool, as are also the commoner kinds of felted hats.

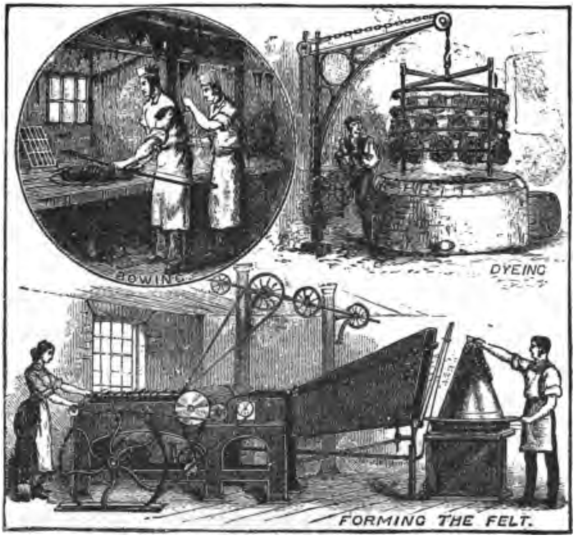
The best felt hats are made of the fur of the rabbit, of the hare, of other similar animals, and of the beaver. In former days the tall dress hat went by the name of beaver, being made from the fine fur of that animal. It is now chiefly the rabbit which supplies the fur for our hats. Rabbits swarm in Germany, Russia, France, and in Australia they have multiplied so fast as to become a pest and danger. They are caught and killed for their fur, which is dried and packed, at the rate of twenty-five rabbits to every pound of fur, yet it reaches our shores by hundreds of tons.

The matted fur is first operated upon, as with cotton and wool, by the blower, a machine about a hundred feet long, with a fan inside, revolving at a speed of two thousand turns a minute. The current of air thus produced effects wonderful results. The fur separates and classifies itself according to its fineness and quality. Coarse hair, and bits of wood, dirt, gravel, or other impurities, being heavy, travel only a short distance before they fall, while the finest fibers, the ones best fitted for felting, are wafted to the extreme end of the machine.

LESSON XII.

For Your Head.

THE manufacture of a felt hat illustrates the work of both fulling and felting. Enough of the loosened fur to make a hat body is weighed out and spread on the feeding-apron of the forming-machine. When the fur is drawn in, it is caught by two rollers, one roller set with wire teeth and the other with lines of bristles, and each revolving at a speed of four thousand turns a minute. From the outlet of the feeder, there proceeds a light drifting shower of short single fibers, sweeping to a metal cone in front. They bind evenly from summit to base round the cone while it slowly revolves, and an attendant turns upon it a fine spray of boiling water.



Making Felt Hats.

We want to know the reason of the strange spectacle. We first find the copper cone to be punched with fine holes. We then see that it is placed over a kind of pit, in which works a fan, called a ventilator, drawing air through the holes, from the outside. The fan works very rapidly, exhausting the air in the pit, which is refilled by the outer air rushing in. We know now that the conical cap of fur is held on by the pressure of the outer air, there being no counter-pressure inside to withstand or balance it. We can also discover the purpose of the boiling spray; for when the workman forms for us a dry cap, we find that only his skillful touch can take it off. When you and I attempt to remove it, we fail, for it proves to be mere fluff, as light as swan's-down, and we cannot hold it. The wet cap, on the other hand, is "set," and even we with care can take it off whole. It still requires gentle handling, however, and easily pulls apart.

The next stage of felting has, for its end, to shrink the cap to half its size. The operation is on the same plan as the fulling of broadcloth — warmth, moisture, and pressure being trusted to as means to close or to full the felt, which gains in thickness what it loses in area. At first the cone of fur is folded and wrapped in a cloth, to protect it while being pressed free from water. The planking-machine completes the process; and the result is a felted hood, capable of being blocked into hats of almost any shape.

The planking-machine is a recent invention. Until lately, a planking-kettle, or caldron of hot water sunk in the middle of a plank or table, round which half-a-dozen men could operate, was used. Each hatter fished out a hat-piece immersed in the hot water, and, by rolling, pressing, working, and re-dipping, caused the fur to become perfectly matted into cloth. Since hand-labor has given way to machinery, a man can plank or felt a dozen hats in the time it took him before to felt one.

When dry, the rough hood, or cape as it is also called, gives little promise of ever being a handsome hat. Like a neglected beard, it wants shaving. The shaver puts the cap on a rapidly-revolving block made to fit, and shaves the surface, not with a razor, but with fine glass-paper.

The hat has still to be blocked into shape. Once more rendered soft and pliable by steaming, it is pulled, stretched, and rubbed, till it takes the shape of the block, upon which it is then held by tacks or cord. The blocker needs all his skill and cleverness; for if he allows the felt to get cold, it becomes stiff and unworkable, and his time and labor are lost.

Again a revolving block is used, this time in the finishing-lathe, where brush, iron, and plush polishers bring the surface to a finish as soft as that of velvet, as smooth as the nap of superfine broadcloth. It remains only to dye the hats. Dyeing is done by dipping a cageful of hats into the dye-vat. Lastly, the trimmer takes them in hand, makes them attractive with linings of silk, and sews on the bands and bindings.

A number of thoughts must cross the reflective mind while looking upon the new methods of felting, so superior to the old methods. Here we have an example of machinery doing the former work of the hand. We are able to trace the effect of the new inventions, both on the old hand-laborers and on our people at large. What has become of the hand-laborers?

Employers would, of course, look round among their trusted hands before seeking elsewhere for new workmen. Men now working the felt-forming machine feel that a dignity is added to their labor when they can produce in a day forty-fold as much as they could produce by handwork. They do not get forty-fold the wages, though the fair day's wages for a fair day's work means better pay than they received when they were hand-workers. They get a special advantage too, worth more than money, as regards their health. Hatters were once very liable to consumption, through inhaling fluff and dust at their work. A beautiful system of exhaust-fans draws dangerous particles away from the workman, and the air he breathes is thus kept clear and pure.

The tendency of machines is not, in the long run, to reduce but to increase the number of hands; to fill a factory with thousands where the workshop found room for tens only. As long as nations exist, methods will be always changing in trade and manufactures.

What does the manufacturer do with so many hats? It is certain that he must sell them, or he would leave off making them. But where do forty times the customers come from? And does the maker get forty times his former profits? If so, it would seem only fair that he should give larger wages to the workers. The manufacturer knows there is only one course that leads to success. He must tempt new customers by the best of workmanship and by lowness of price. Cheapness of production, which he secures by machinery, enables him to share the profits. Part he sets aside for his men's wages. Part he allots for his own benefit, as a fair reward for his foresight. The main part, however, of the profits goes to the customer in reduction of price. The maker dares not grasp at an undue share for himself, for he well knows that other makers would soon cut him out of his trade by their more moderate charges. Thus all get their due shares — the workman in his wages, the seller in his profit, and the buyer in the choice of cheap and excellent hats.

LESSON XIII.

Furs.

THE fur animals range through the wide and dreary plains which shelve down to the Polar Ocean and encircle its frozen waters. Since the settlement of Canada, the hunting-grounds of North America have furnished more furs than the Old World. Few human beings can live in the frozen bogs where the fur animals abound, and those lonely wastes are abandoned to the trappers and their precious prey. Fur-bearing animals are mostly small but fierce, with sharp teeth and a thirst for blood. Their bodies are usually slender and supple. It seems strange that such cruel little beasts should be clothed in such delicate, beautiful, soft fur.

In Rupert's Land, the name by which the former possessions of the Hudson Bay Company are known, the Indians trap these little creatures, and bring the skins to trading stations or forts, raised, at long intervals apart, by factors or dealers, who store up the season's fur supply, and bring it down the rivers to port. The cargo reaches London in September, and a great sale of furs takes place the following March. The various kinds of furs brought to the London market number several hundreds, the most costly of all being the pelt of the sea-otter. Of the Russian furs, sable is the most expensive, yet 25,000 sable-skins are sold yearly at Leipzig Fair, the

Fur Animals.

chief mart of Russian furs. Another market for those furs is Novgorod. The fur next in value to sable is Russian ermine. The ermine is a snow-white, gliding creature, with the tip of its tail black.

These rich and costly furs have been worn as robes of office for many ages, to show the rank and dignity of the wearer. In former days none but the nobility might wear them. The black tails of the ermine, inserted into the fur, were placed according to strict rules, to show by their number and arrangement higher and lower degrees of honor. The English judges used to wear ermine robes: the "purity of the ermine" is a figure of speech which refers to the belief that the judges could not be bribed to decide cases unjustly.

Workers in fur are called furriers. "Fine work" takes in the sable and the ermine, the beaver, the otter, the marten, and the shrew. "Common work" includes the skins of the wolf, fox, lynx, badger, bear, and seal. "Gray work" comprises the furs of the gray squirrel and the domestic cat; "variegated work," those of the marmot and the brown squirrel; and "spotted gray work" means a mixture of these last two varieties.

Many of these furs are dyed to imitate better kinds. Every sort of fur is of value, and none is wasted. Thousands of women find work in joining neatly small cuttings and pieces, to make collars, bows, muffs, and trimmings. When the fur is smoothed all one way and the work is well done, it would try keen eyes to find the seams.

LESSON XIV.

Seals.

WE are all aware of the value of sealskin as a fur, but the life history of the animal which provides us with it is not so generally known. Long years ago fur seals could have been found in great numbers in the South Pacific and South Atlantic. The islands off the shores of Patagonia swarmed with them. But these facts are now ancient history. It may be said without fear of contradiction that nearly every sealskin offered for sale in the United States during the past twenty years came from certain rocky islets in Bering Sea.

The seal islands consist of two groups, — the Komandorskis and the Pribilovs. The former group, comprising Bering and Copper Islands, are the westernmost links in the lonely Aleutian chain. They belong to Russia, but are rented by an American company. The Pribilovs — St. Paul, St. George, and Otter Islands — lie well within Bering Sea. They are far more valuable than the other group, being capable of exporting, in a good season, as many as 100,000 pelts. These five islands are the only camping-grounds of the North Pacific eared, or fur, seal. Why so restricted a territory should have been chosen by the seals, it is very difficult to explain. There are, without doubt, many other places just as fit for them; but habit, we know, has as much influence over the lower animals as over ourselves. Hence it happens that, year after year, each fur

Seals.

seal visits the island to which it is accustomed, never moving to fresh ground, and only rarely going to the other islands frequented by its kind.

Zoölogy, the science of animal life, furnishes us with few objects for study so strange and interesting as this furry creature. It is an animal which spends one-half of the year entirely in the water and the other half almost entirely on land; which herds together in vast crowds in a manner unknown in the case of any other brute creature, and which exhibits, in its mode of life, an intelligence almost as wonderful as that of the ant.

When the Russians first took control of the territory now called Alaska, they wantonly slaughtered seals of all ages. On the islands of St. George and St. Paul the pelts accumulated to such an extent that, in 1810, no fewer than 800,000 were lying in the storehouses. So little care was taken of these costly skins that 700,000 had to be thrown away! For some time this shocking and useless slaughter was continued, and then the seals began to decline rapidly in numbers. In 1835 only 6,500 skins were obtained.

The Alaska Commercial Company has held from the United States, since 1870, a lease of the Pribilovs; and the seals killed have been carefully chosen. As a result the numbers of the animals have been steadily raised until now the "rookeries," the camping-grounds of the seals, are in the condition in which they were found by the discoverers of the islands.

A rookery is one of the most astonishing sights that the world affords. For miles along the seashore one sees a densely packed and ceaselessly moving crowd of animals. The air vibrates with a dull, heavy roar whose evenly blended volume of sound is, from time to time, broken by the louder bellow of some old warrior seal, or the high-pitched *ba-a* of a puppy hard by. Constant activity is the leading feature of the scene. Closely crowded as are the multitude of creatures, the mass is, nevertheless, divided here and there by paths along which many of the younger seals are passing to and from the sea.

The puppies, all of them black — the old seals are dark-gray — are, some, joyfully diving in the surf, some playing on the beach, while others are sleeping near their mothers. The variety and the oddness of the attitudes assumed by some of the young seals astonish and amuse the spectator. Here is a puppy curled up, his tail covering his nose ; there is another slowly fanning himself with his hind legs — flippers, these are called ; another carries one flipper on his back, like a tail, and another has his head thrown up in the queerest imaginable manner, as if his attention was fixed solely on the condition of the sky.

The rookery is divided by the seals themselves into districts with definite boundaries. There are quarters for the mothers and the puppies; the other seals have sections for themselves; and there is a hospital ground, a refuge place for the sick or those disabled in any of the combats constantly arising between the older seals. Such is a rookery, a swarm of perhaps 300,000 restless animals, fighting, playing, swimming — all to an unceasing concert of nearly as many voices.

In winter the islands are deserted, the seals having gone to the warmer water of the Pacific. But they return late in spring, the old and strong preceding the younger ones. The animals begin to depart in August, the older ones going first. By this time the puppies have learned to swim. Curiously enough, swimming is not an art that the young seal knows by nature; he has to learn it by practice.

After the seal is six years old the skin grows poor in quality; and if the animal is still older, it is almost worthless. The pelt of the puppy, on the other hand, not having reached its full size, has also not reached its full value. The most desirable skins are those of seals between the ages of two years and five. These seals are selected from the rest of the rookery, to the number wanted, and are driven at the rate of half a mile an hour to the place of execution. If the animals were driven faster, not only would most of them die of exhaustion, but the fur of all would be spoiled. Staffs, each one six feet long and knobbed with lead, are used to kill them. As soon as they are killed, the skins are removed, salted, dried, and bound in bundles, ready to be transferred to the company's steamer, which takes them to San Francisco. From that city they are sent to London to be dyed the dark-brown color familiar to us all in sealskin fur. Having been dyed and finished, they are ready to be made into wearing apparel.

The Atlantic seal is a very different creature from the noble and intelligent animal whose coat is composed of the much-prized fur. The former seal is covered with stiff rough hair which possesses no mercantile value whatever. The skin of the young of this seal, however, is useful, and more useful still is the thick layer of fat beneath the skin. Shoes, harness, purses, valises, instrument cases and other articles are made of the hides, and a valuable commercial oil is extracted from the fat.

During the winter the Grand Banks, off the coast of Newfoundland, form the chief feeding-grounds of these seals. Early in June they start north for their summer resort, the Arctic ice, which, in vast fields, each one hundreds of square miles in area, drifts down toward the Labrador coast.

Terror seizes on the animals when they catch sight of a steamer. This event is likely to occur a good while before the crew catch sight of the seals. In fact, a chorus of cries of alarm, borne by the wind to the ears of the hunters, is usually the first notice that a seal "patch," a rookery on the ice, is not far away. Soon, moving black spots appear in the distance, and the steamer's crew is thrown at once into the wildest confusion. The hunters, perhaps three hundred in number, spring out upon the ice. With gaffs and knives they rush upon the "whitecoats," the puppy seals. The shouts of the men, the continuous rumbling of the ice, the angry roars of the mother seals, the frightened, pitiful cries of the puppies, sounding exactly like the sobs of children in distress, all produce a tumult terrifying to hear.

It is the puppies that the hunters are after. The coat of the young seal is white and almost fur-like, and the heavy lining of fat, which protects the carcass against the cold, contains a large percentage of valuable oil. A single blow with a gaff — a six-foot club — on a whitecoat's nose is enough to stun him. Then the hunter whips out his knife, and in a minute the skin and the fat are stripped off, and the poor little creature's carcass is left quivering on the ice. A puppy's pelt in its best condition is about three feet long, two and a half feet wide, and weighs about forty pounds. From 30,000 to 100,000 seals are often found in a patch. So quickly can the hunters work that they often load their steamer to the gunwales in ten hours.

But, to get a full cargo, a thousand risks must be run. The chief one is stormy weather. Nothing more fearful can be imagined than the action of the ice-floes under the influence of raging winds and seas. Icebergs, millions of cubic feet in size, are dashed against each other, breaking into blocks with a crash that would drown the roar of ten Niagaras. Many a fine vessel has been crushed into splinters between those terrible mountains of ice. Crews are sometimes obliged to abandon their steamers and to take the desperate risk of trying to reach land by leaping from one cake of ice to another. They seldom succeed. Stories of ordinary ocean perils, shipwreck, famine and fire, are dull, indeed, compared with the tales many seal-hunters tell of their adventures on the ice off Labrador.

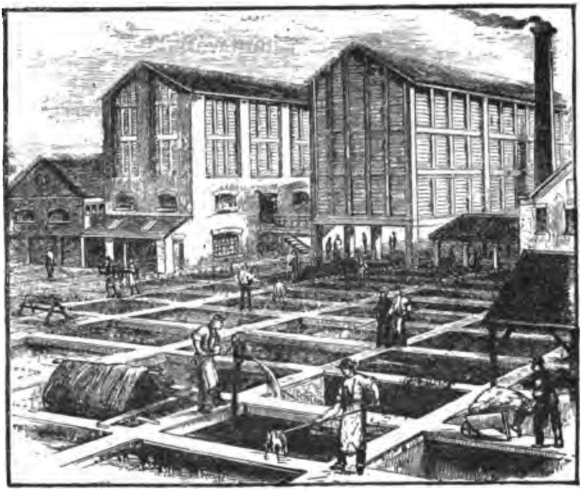
Lesson XV.

Tannin and Tanning.

Let us enter this broad gateway which opens upon a spacious court, in which we see numerous pits of lime and tan. Water-courses traverse the yard here and there, fed from a huge tank. Tubes, with taps, connect the pits, and a tanning infusion passes on from one to the other, drawing out, in turn, the strength of several supplies of bark, till the liquor becomes of first quality. Near at hand, a mill is grinding the bark. Its grinders can soon demolish a goodly meal, while, from the loud grumblings inside, one might fancy it to have been kept lately on short commons. Oak bark is still the favorite tannin-yielder despite all the efforts to find other tanning substances.

Powdered sumach ranks next to oak bark in importance to the tanner. It consists of the dried leaves and stalks of a shrub of the same name that grows throughout the United States. Valonia, large acorn cups, from the Turkey evergreen oak, reaches us by thousands of tons, to add to our stores of "bark." The various stages in leather-making present beautiful illustrations of the chemistry of common things, showing how science enters into an everyday work of practical life. There is little need to travel away from home to find marvels to interest or to surprise us.

Following the hides and skins as they come to the tannery, we first observe groups of men,

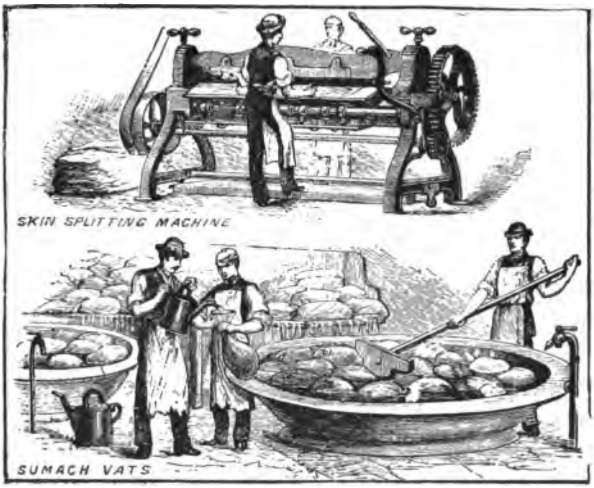


A Tannery.

in leather leggings and gloves, "handling" them in the lime-pits. The slippery substance, into which weeks of soaking have changed the skins, glides through the workers' clutches as easily as an eel through the fingers. The men hook up with long poles the skins floating in one pit, and slip them over into the next and next. The process is repeated, day by day, until the rotting roots of the hair are loosened, and the fleshy matters on the other side are easy to remove. The time taken in these operations must be regulated by the thickness of the hide; but the end is always to reduce the substance nearly to gelatine, with which tannic acid has a chemical power of combining to form a third substance, which is quite different from either the acid or the gelatine, and is known as leather.

Every kind of skin may be tanned into leather, from the most delicate membrane to the hardest, strongest hide. The skin of a living creature is usually so soft that it seems not durable. Fancy skins are tanned, at times, for special purposes. Shagreen, a leather produced from the skin of the sturgeon, finds use as a covering for cases of drawing and surgical instruments. Alligator skins, with their plates intact, make the strongest and most lasting bags and purses. Tannic acid takes years to convert elephant and rhinoceros hides into leather. Thoroughly tanned, they are heavy and thick, resembling rough india-rubber.

Patent leather is produced by a process of japanning and varnishing. Calfskin is first freed from every trace of grease on its grain side, and the surface is then carefully shaved, smoothed, and polished by suitable tools. The varnish is applied on the flesh side of the leather, and the japanning material on the grain side. Then the leather is placed in hot rooms to dry. The japanned side is polished, again coated, dried and polished, the round of operations being repeated until the required glossiness is obtained.



Tanning Machinery.

Among the many clever contrivances in aid of industry which have made our time the age of invention, the skin-splitting machine takes a high position, for the skill and thought displayed in its construction. By its aid, the grain side of a hide of leather may be severed from the flesh or under side, and two hides produced out of one.

Try to think what it means to separate a thin layer of gelatine into two thinner layers. It would seem as easy to divide a leaf of paper into two leaves. Looking at the machine, we see two rollers, which, as they revolve, one above the other, close enough to bite the soft thin hide, present the skin, as it comes out on the other side, to the action of a keen blade, moving to and fro, and so well adjusted as to slice off only a filmy surface, or to give equal thicknesses, as wanted.

The "grain" is not treated in the ordinary way. The "flesh," if very good, is tanned, and in the case of split calfskins, is the source whence the covering for law-books comes. Mostly, however, the flesh goes for manure,— a wanton waste to our eyes, and waste, we thought, was not allowed in the economy of modern trade; but we learn that the jelly so quickly runs to water, that it cannot be utilized with profit even for glue or size. Recent improvements have adapted an endless, flexible band-knife to cutting or splitting every kind of skin and hide, thus doubling the sheets of leather; and it leaves each surface so smooth that it will take a polish and a grain.

Leather, tanned and dried, has to be reduced evenly, well stretched, and rendered supple. For these purposes the curriers and dressers take it in hand. Hides are curried on a polished beam. The curriers' knives "strike" at the skin with much force, taking off the excess of curriers' oil, a composition of oil and tallow, which has been well rubbed in. Oil retains its hold upon the leather, not going off into vapor as water does, and it imparts a softness which the substance does not again lose. Another drying in a warm room, and

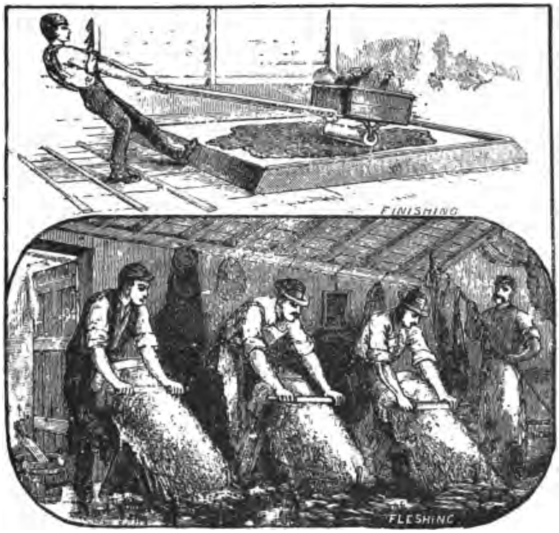
Finishing the Leather.

the leather is ready for the trough of the dyer and the tool of the finisher.

The black surface of leather is given by rubbing in with a stiff brush a liquid preparation of iron, which, uniting with the materials used in tanning, makes an ebon black. Morocco and imitation morocco from sheepskin are, on the other hand, dyed. The dyeing-house is an interesting sight. We see no steam, no fire. The smooth surface of the dye in the vats begins to move, then bubbles, and in five minutes becomes a heated and colored whirlpool.

Iron pipes, conveying steam from the engine, dip into the dye, and speedily raise it to the boiling-point. Here is a thick Black Sea, heaved up as though the fiend of strife abode beneath; there a Red Sea, as furious as that one whose waters returned to overwhelm the Egyptian hosts; near at hand is a restless Yellow Sea, more turbid and shallow than the one which laves the China coast. Cochineal is used for the brilliant reds, and is a dear commodity. As only one side needs dyeing, cost is saved by sewing the pelts round the edges, and dipping them with the grain alone in contact with the dye.

After the coloring, the grainer "pommels" the skins until they are soft. As he folds the hide under a small flat board fastened to his hand by a strap, and rolls it to and fro, it becomes softer and much more pliable, and receives its admired grain. Another plan of graining is tried for the finest skins, which are placed on an elastic board, while a wheel of hard wood plays upon their surface. The wheel is connected with a hinge in the roof-beam, and as it runs over the yielding board, it leaves ridges upon the leather, corresponding to furrows cut in its own tire or circumference. The process is repeated with a dummy, or smooth-surface wheel, to produce a polish.



Fleshing.

The manufacture of wool mats and rugs is distinct from the tanner's art, but is, however, a branch of the work of some large tanneries. We notice a square lake in the open yard, where a strong fellow stands working in water, up to his knees, with a long pole in his hands, pointed with a cow's horn. With this strange tool he tosses, turns, and cleanses the woolly skins floating on the water, until he has got all the grease out ; then by scrubbing with soap, he makes them as white as snow. The great triumph is in the dyeing-house, where the feat of dyeing a skin black has at last been accomplished. Glancing over these mats, when finished with deep thick fringes, we think that nothing more silky-soft can touch the hand, nothing brighter meet the gaze.

LESSON XVI.

Foot-gear.

To design a house properly an architect must understand the wants of the persons it is intended to shelter. It would seem to be equally necessary that the artisan who is to furnish protection for the human foot should know something of its anatomy. The needed information is not hard to be got. Shoemakers generally, however, have but little knowledge of the arrangement of the bones of the foot. Yet how is it possible that a maker of boots and shoes, ignorant of the foot's structure, can make a suitable covering for the foot?

In build the human foot is an arch composed of a series of bones which are united in the manner best adapted to secure elastic strength. Hence, if a boy should jump from a height, alighting on his heels, he would jar his frame, perhaps severely; but, if he should alight on the forward portion of each foot, the shock received would be but slight; for the weight of his body would be thrown on the arches formed by the bones of the feet. The arch of the foot is, of course, not solid; and, indeed, if it were solid, it would render walking a painful exercise.

When the foot is at rest the toes touch one another. In walking the toes separate slightly, and the foot spreads out. This spreading being natural, no sensible person would attempt to restrain it by wearing tight foot-gear. Still, it is restrained by the commands of silly fashion, by the folly of the wearer, and by popular ignorance of the foot's mechanism.

Only one person in a thousand allows the foot to widen to the extent naturally required in walking. The lessons taught by the science of anatomy warn us against narrow-toed foot-covering, and also teach us that the high heels, so often put on ladies' shoes, are still more injurious. They cause round shoulders and curvature of the spine, and they destroy that nicely adjusted balance of the frame by means of which nature produces an easy and graceful carriage.

It would be almost as difficult to name the period when foot clothing was first worn by man as to fix the date of his existence. Some of the most ancient records we possess make allusions to foot-gear of some kind. Sandals were worn by the ancient Egyptians and the people of the East generally, and were made from strips of papyrus plaited into a sole.

A very similar sandal, formed of twisted straw, is worn even to-day by multitudes in Central Asia, India, China, and Japan. The papyrus of Egypt was the plant which furnished the world also with the papyr, or paper, used by all writers in old times. Untanned skins of animals were employed as means of protection for the feet at least three thousand years ago. The earliest form of foot-covering was, no doubt, the sandal — a sole-guard and its fastenings. These were made of linen, hide, twigs, reeds, flax, bark, broom, and various other materials.

From the Greek and Roman classics we learn that boot, shoe, and sandal making was practiced as an art in very early times; and, moreover, we are told that differently fashioned foot-casings were prescribed by law to be worn by the different classes of people in order that every one's rank might be readily known. Slaves went barefooted; the poorer grades of the free populace of Rome wore wooden shoes; buskins — long boots with thick soles — were appropriated to tragedians; the plebeians used sandals; patricians only were permitted to wear shoes, and red-leather boots were reserved for senators. Every grade of civil and military life had its appointed kind of foot-gear.

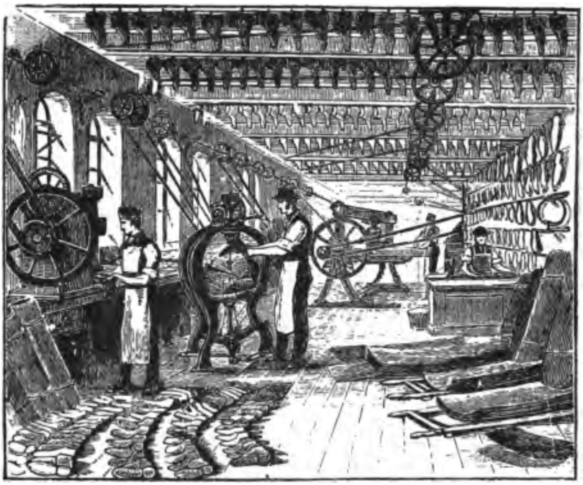
The famous Latin writer, Seneca, records the fact that Julius Cæsar, the greatest of the Roman rulers, wore shoes of gold.

During the Middle Ages shoes were made of silk, satin, velvet, and indeed of every other kind of woven fabric then generally used, as well as of leather. Ornamentation of all kinds of shoes was carried to an absurd length. Half-boots with long toes, so long that they had to be held up by laces fastened to a belt around the wearer's waist, were commonly worn by gentlemen in the fifteenth century. About two hundred years ago the rich people of Venice wore high wooden clogs so clumsily fashioned that walking with them was a series of staggers instead of ordinary steps.

From the sandal grew up the slipper in which fastenings are dispensed with, and a sufficient upper of leather or softer material is provided to keep the article on the foot. The ordinary short shoe is the next development, and from it was evolved the boot. The "shoe" frequently alluded to in the Old Testament was a sandal. It played an important part in buying and selling, and in social usages. Sandals of odd style have been found on the feet of Egyptian mummies embalmed a thousand years before Christ was born.

A last is a piece of wood or iron, shaped to resemble the foot, and is employed as a model in the formation of the boot or shoe. Its use has been traced back to a very early period. Sandal-makers did not require a last because the sandal did not envelop the foot. When, however, shoes with uppers were designed, the last became a necessity. It was found that the shoe would soon be trodden out of form, if it differed materially in shape from the foot. The workmanship of the first lasts was extremely crude, and not till last-making became a distinct branch of industry did any great improvement appear in last forms and manufacture. Division of labor proved its value here as well as elsewhere.

The rapid march of improvement is in no trade more forcibly illustrated than in shoemaking. It is hardly fifty years since shoemakers first attempted to utilize machinery. The earliest innovation was the use of the sewing-machine to sew uppers together. Now, a shoe can be made entirely by machine work. Soles, lifts, uppers, toe-caps are cut out, each one at a single stroke, stitches are set with the speed of lightning, pegging or nailing, pairing and finishing are done so swiftly that the untrained eye cannot follow the motions of the machines.



Shoe-making Machinery.

Sewing with brass wire on which a screw thread is worked, is one of the most recent improvements in the manufacture of men's heavy shoes. The machine doing this sewing uncoils a reel of prepared wire, drives through the thick sole-leather a portion of the wire, and cuts it off flush with the outsole, all the operations being performed with extraordinary rapidity. The last stronghold of hand-labor in shoemaking was captured when a machine for working buttonholes in shoe uppers was invented. So nearly perfect are all the machines that their tenders have little to do except to feed them with the required materials.

The sewing-machine was first used in making clothing, and its great value in that branch of industry led some intelligent workman to employ it to stitch shoe uppers. It was a success from the start. Then, inventors turned their attention to the devising of a machine capable of sewing the sole to the upper. Shoemakers scoffed at the assertion that a machine might be produced that could force waxed thread through outer sole, packing and inner sole. It was not long, however, before hand-sewers began to query whether their occupation would not soon become one of the lost arts.

The first sole sewing-machine was far from being all that could be desired, but numerous improvements have brought it near perfection. In its present form it draws a stout thread through the thickest sole leather as easily as an ordinary sewing-machine sends a needle through calico. The success of the machine has been marvelous. To it New England owes, in no slight degree, her important industry of shoe-manufacturing.

By means of this machine, soles can be sewed on a hundred pairs of women's shoes in an hour. The pegging-machine makes the pegs and drives them into the leather in two motions, pegging a shoe in ten seconds. More wonderful still is the electric nailing apparatus. A galvanic current sets in operation a series of hammers, which, with amazing speed, finish a row of brads or a surface of hob-nails, and do the work with a nicety that no manual skill could ever equal. What marvelous advances are these new methods over the slow, laborious ways of the cobbler!

In this country the factory trade, in boots and shoes, has developed remarkably since 1865. But that trade would never have reached its present volume, shoemaking in huge factories could never have been profitable, if American inventive genius had not produced, in rapid succession, a number of wonderful machines, triumphs of mechanism, which increase man's working power ten-thousand-fold, There are to-day more persons engaged in the United States in the various leather industries than are employed in the woolen, silk, linen, and cotton manufactures.

LESSON XVII.

A Trade's Oddments.

MOST young people have read about the American "buccaneers" — pirates that roved West India waters and the Caribbean Sea, about two centuries ago, robbing merchant vessels, and sometimes murdering the crews. It is not generally known, however, that the men to whom the name was first applied were honest and hardy Frenchmen who settled, in the early part of the seventeenth century, on the beautiful island of San Domingo. There they set to work hunting the wild cattle, which then swarmed in every part. The meat they preserved for future use by smoking it. The term "buccaneers" was given them by the Carib Indians, and means "smoked-meat eaters."

For the surplus of meat customers were found in the crews of the numerous vessels which touched at the port of San Domingo. Perhaps it was the demand for the meat that led those French settlers to reflect on the value of the cattle-skins which they obtained so easily. But before those skins could be sold, they would have to be put into marketable condition. A rough process of tanning was adopted, and a large trade in the hides of cattle and wild animals soon sprang up.

But of course such profitable trading could not go on long without arousing competition in other West India colonies. Cuba, Jamaica, Porto Rico, and several smaller islands, began to raise cattle and to export hides and smoked meat. Some of the San Domingo buccaneers were thereby forced into idleness, and, rendered desperate by hunger, they seized on a vessel, sailed away, and became pirates. In a short time they forgot that they had ever been honest, peaceful workingmen, the first tanners and curriers in the New World.

Among the many articles now made in the Orient from leather, perhaps bottles are the oddest. Once they were common enough all over Christendom. In England they were used before the days of casks and glassware. Bottle-makers in the times of the Crusades were well-paid craftsmen. Every soldier and every pilgrim that set out for the Holy Land provided himself with a leathern bottle that he might have with him an unbreakable utensil in which he could carry water to drink on his long, toilsome journey.

Any liquid which has to be conveyed on a camel's back can be transported more conveniently in a yielding bag than in a barrel; and, therefore, a considerable trade in bottles made of leather is still done in North Africa, Arabia, and Palestine. The Arabs make the bottles, as nearly as possible, of the same size, and sometimes of double skins; but even in this last form they are often unable to resist the withering heat of the desert, and the water in them evaporates, leaving men and animals to die of thirst.

Sometimes a river has to be crossed, and no boat is to be had. A raft is quickly built by blowing the bottles full of air and tying them together. A flooring of light boards is laid on them, and they are ready to transport goods or passengers to the opposite bank. Leathern bottles are usually made of goatskin. If cowhide is used, it is soaked in lime-water till the hair loosens; then the hide is put into a bath of whitewash, unhaired, and lastly drawn through running water several times. It is sewed with the flesh side turned inwards.

How is the beautiful Russia leather prepared? In Russia, workmen of all kinds are formed into clubs, or companies, entire villages being often inhabited by families employed in special trades, such as carpenter work, machine-making, boat-building, and other occupations. Most of the tanners live in Tver, a city having a swiftly flowing river running through it. Fresh water, we have learned, is necessary in the process of turning skins into leather. The headquarters of the association of leather-workers making the most costly kind of Russia leather is at Tarjok, on the banks of the river Tversta.

This celebrated leather is made from skins of sheep. The skins are placed, fleshy sides up, in large vats, and covered with a thick mixture of ashes and lime, dissolved in water. After being unhaired and tanned, the hides are sewed up so as to form bags. These are filled with bear-berries, and willow and oak bark ground fine. Next, the bags are fastened up tightly, and put into vats in which is a thin liquid mixture of the same tan, kept cold by ice. When it is judged that the skin-sacks have lain in this tanning liquor long enough, they are ripped open, washed, and dried. Then they are steeped in a hot infusion of sandal-wood, and finally are "finished" — that is, the surface being rubbed with linseed-oil, and the fleshy side with chalk, the right side is smoothed and polished to the fineness we expect in Russia leather.

There is a very common and useful article employed by our shoemakers, which comes also from Russia — the bristle, the shoemaker's needle. Bristles arranged in bundles, large and small, and inserted in different kinds of handles, are employed for brushes for the hair, teeth, nails, for shaving, for dusting off furniture, and for various other household uses. Without bristles our painters and decorators would be compelled to stop work; our artists, deprived of their dainty little brushes, could not produce any beautiful pictures; and the brush factories would have to close their doors, leaving many persons without work.

Unlike any other hair, the bristle has many sides, is double-tubed, is smooth on its outer surface, and ends in a kind of brush of many points. It is this last-mentioned peculiarity that makes threading possible. When the cobbler puts a bristle on a wax-end, he splits the thin points of the hair into about half a dozen parts, then divides his flax thread into as many, twists bristle and thread together by a few rapid twirls from thumb and finger, and completes his work by coating the thread with wax.

About a million pounds of bristles are annually imported into this country, the greater part coming from the vast forests of northern Russia, where thousands of square miles of land are covered with oaks, beeches, and berry-bearing trees. In those pathless woods swarm numberless herds of half-wild swine, — lean, muscular, scraggy brutes, the leaner they are the stronger are their bristles. They shed these by rubbing themselves against trees; and men, carrying sacks made of ox-hide, go through the forests, collecting the bristles for market.

In some cases hogs are reared specially for certain bristles. After a period of unlimited feeding on the refuse of some great tallow-factory, piggy is supposed to have brought his crop of wiry hairs into the best possible condition. Then he has to pay for his board in a fashion he little expected.

When the harvest-time for bristles has arrived, crowds of the hogs are driven into large fenced inclosures. Kicking, struggling, grunting, squeaking, and pushing one another, they work themselves up into the state of heat considered necessary, and then the keepers set to work pulling out the longest bristles. You may readily imagine that this task is neither an easy nor a quiet one.

LESSON XVIII.

From Foreign Lands.

HAVE you ever noticed in the windows of large shoe-stores pretty slippers of bright-colored morocco, red, blue, or yellow? Some of them may have been decorated with gold or silver thread, or covered with tiny spangles. Such slippers, or soleless shoes, were first brought to this country from Algiers. They are made of "filati," a kind of fine sheepskin.

The embroidered slippers, imported into the United States from North Africa, have been adorned by men — not, as one would suppose, by women. The embroiderers use fine wire for both needle and thread, and do remarkably tasteful work. Nowadays, fancy slippers, made of various tinted leathers, are manufactured in large numbers in the United States and in Europe.

The curriers of Algeria prepare plenty of other skins besides those of sheep and goats, but the natives of that country will on no account allow the hides of their dead horses to be tanned. The Arab regards his horse as a friend and companion, and, when the creature dies, he takes care that its carcass shall not be disturbed.

The Kabyles, a wandering tribe of Morocco and Algeria, are daring hunters, and supply European traders with hundreds of wild-beast skins yearly. These are carefully dressed by a special process, and are used as ornamental rugs. Lives full of peril are led by those fearless Kabyles who pursue the dangerous occupation of hunting the fierce "man-eaters" (lions) and other savage animals that roam the North African deserts.

One old Algerine, known as El Muffa, whose only firearm was an ancient musket, had the reputation of having killed more than a thousand lions and panthers. In the market square of Blidah, a city in Algeria, he offered for sale, at one time, the hides of fifty-three lions, all slain by himself. What courage, self-reliance, and skill that lot of hides represented!

In modern times the covering for the hands as well as for the feet is made of leather. Is it not strange, however, to learn that the kid gloves with which we are all familiar are not gloves of kid? The kid glove sold in our stores is made from the skins of goats, sheep, and lambs. These skins are not tanned; but by a slow and peculiar process, called tawing, they are turned into leather suitable to be made into gloves. Nearly all the tawed leather and fine gloves come from France.

When the skins have been cleaned and dyed they are allowed to grow hard and dry. Then they are moistened and soaked in wet bran. After soaking for some time, they are taken out, dried, and drawn backwards and forwards over a strip of steel, looking much like a long blunt knife. This, fixed in a strong heavy frame, enables the workman to stretch the skin in every direction without missing an inch of the surface. By this operation the leather becomes so soft and smooth that it bears hardly any resemblance to the former rough hide.

Yet, if we follow the future glove material to the next department, we shall see further improvement produced by "paring." We notice that the parer, whose left thumb has a heavy leather sheathing, wields a curious-looking tool half-circular in shape, having a handle on the inner side. Dexterously paring here and there, he removes all the little lumps he can discover, a task that requires a sure hand and practiced eye; for, after being pared, the *kid* skin is considered fit to be passed on to the sorting-room, where it will be placed with other skins of about the same size and quality.

The first step in glove-making proper is the "cutting-out." This operation is quite important. A new hand would spoil a good many pieces of leather before he could shape a glove that would pass a critical inspection. The cutter stretches the skin across the center as far as it will go, and then carefully measures the width; then he pulls it lengthwise and measures it again; lastly he smooths it out.

Placing an oblong wooden pattern on the skin, he cuts out, with a sharp knife, the two sides of the glove — no thumbs nor fingers, remember, but simply long, four-cornered pieces out of which the upper and under sides of a pair of gloves can be made. These pieces are laid together, and when a pile containing three or four dozen of them has been formed, it is taken to the "punching-room," where the final shaping is done. Each piece of leather is put on a steel form — a thumbless hand — white paper is placed on the leather, all are adjusted in the bottom of a press, a lever is moved, the top of the press falls and flies back, and the glove is half cut. The work is completed by cutting the thumb-piece in precisely the same manner.

It requires usually four persons to finish the glove — one sewing the fingers and thumb, one hemming the wrist, a third attending to the button-holes and buttons, and the fourth person stitching the seams on the back. The seams are, however, often worked by means of a sewing-machine. The heavier kind of gloves are entirely machine-sewed. Kid-glove sewing was done by the help of a small vise in which the edges of the glove were held even by two saw-like metal strips, until the sewing-machine was adapted to this work. The machine used to sew gloves has its needle set level. This, driven by steam, runs with great speed, making the neat stitches of silk thread, which we all know well.

Kid gloves that are really gloves of kid may be obtained, if the buyer is willing to pay the price. They are made in Vienna, Berlin, and Paris from the skins of kids killed on the Swiss Alps or on the Balkan or the Carpathian mountains. It is a puzzle to the traveler to know how the numerous herds of half-wild goats manage to exist on the scanty supply of grass and aromatic plants which they often can procure only by leaping from one perilous crag to another. The poor mountaineer would be badly off without these little creatures. They supply him with milk, butter, and cheese; their meat is good either fresh or smoke-dried; their hair fills his mattress, or is sold and sent to distant cities, where it is manufactured into rope, mops, brushes, yarn, and even wigs.

The goat whose skin furnishes glove leather is a very different animal from the izzard, or chamois goat, which has been hunted so persistently that it is now very scarce. Its skin is valuable and its flesh savory, so that it is little wonder that the chamois has for many years been the favorite game of the Alpine sportsman. It is a pretty sight, though a rare one nowadays, to see a herd of izzards on some far height of rock, seeking for food, one of their number acting as sentinel and keeping a sharp lookout. The rest, as they wander here and there, browse apparently in perfect security; yet, at a signal from their watchful guard, they will in one moment vanish from sight, disappearing among the snow-covered crags.

Swiss kid-skins are collected by dealers who, beginning on the Italian side of the Alps, move northwards keeping up with the kid-killing of the mountaineers, as the summer advances. These dealers visit the most remote places. They sell their wares to great wholesale merchants who have storehouses in Frankfort-on-the-Main and Leipzig.

Large supplies of glove-making skins are furnished by India, South Africa, Morocco, and Asia Minor, while Mexico sends us the "tampico" — a kind of skin which surpasses all the others in size and quality, and is very valuable.

Gloves remarkably fine, soft and, delicate, are made in Paris out of very singular materials — the skins of rats. These rats are killed in the immense sewers of the French capital by men who make a business of supplying skins to tanners of glove-leather. In this country the skins of deer, hogs, and sheep are often made into "handshoes," as the Germans quite appropriately call gloves. The chief center of our steadily growing glove industry is Gloversville, New York. In that village nearly four thousand people depend for their living on the glove factories. In several other towns machinery is used in making kid gloves, but these are sold generally under French names.

LESSON XIX.

Wealth Production.

WE have read about the food we eat and the clothes we wear, and have seen that man trusts to his labor for these things; and we have also had to notice, that there are other things which he needs quite as much, but which his labor could not provide. The sun that gives us light and warmth, the water we drink, the land we live upon, the air we breathe, would exist, if men ceased to live. Man never has added to the sun's heat or light, or to the air, the water, or the land. These things differ from food and clothes in being ready made for us, and they could not be produced by any effort of our own; while food and clothing do not exist in forms fit for use, but must be provided by labor.

The term WEALTH has been given to those necessaries over which man has control, and which are products of labor. We may say of the supply of the sun's light and heat, of air, and water, that there is no limit; yet many people suffer from impure air and from want of sunlight through living in crowded rooms and in unhealthful places.

Historical Costumes.

Lessen the supply or the purity of any of these necessaries of life, and health and strength lessen; diseases increase; the old, the young, the ailing and feeble, are cut off; the death-rate rises. This truth explains why deaths are more numerous among the poor than among the rich. Plenty and variety of food, abundance and frequent change of clothing, mean better health, greater strength, more comfort and happiness, longer life. The lives of savages, as a rule, are short, because they so often suffer from hunger. On the other hand, Americans live longer than they used to live, because they are always adding to their knowledge and therefore to their stores of wealth.

With wealth man can better house and clothe himself. Thus fewer die from want and exposure. Wealth also relieves a man from working in dangerous places. It is because men and boys have more dangerous work to do than women and girls that more males die every year than females.

Each worker does not produce all he wants. Shoemakers want coats, yet they do not weave; sailors want food, yet they do not till the soil; the weaver wants shelter, yet he does not build a house; another workman, who needs fuel to warm him and to cook his food, applies himself to the making of steel pens. They all expect to produce more by keeping to one trade, than by attempting everything and doing nothing well. They know the old saying to be true, that "Jack of all trades is master of none." Practice makes perfect. By constant efforts only do artisans become skillful.

There are two fellow-workers — nature, which gives the raw substances, and man, who finds out the best means of working up these substances, and carries out with his hands the ideas of in-industrial progress that arise in his brain.

Look at your cloth coat. What has nature given towards it? The wool of the sheep; which, we must notice, is not quite a free gift, for we must rear and tend the sheep. What have the hands done? They have spun, then woven; but the mind had first to think of a spinning-wheel and a hand-loom, then of carding and knitting frames and self-acting power-looms, — machines which have given to the hands the power to do a thousand times their amount of work. So, also, through all our lessons on the food we eat, and the clothes we wear, we found that in every branch of labor Nature had provided the raw material, the mind had directed the processes of utilizing this material, and the hand had carried out the orders of the mind.

Some ideas of sale must have been in the hatter's brain before he set about making hats, and in the mind of the shoemaker before he applied himself to the making of surplus shoes. Each knew that the farmer, the tailor, and the butcher would be glad to sell some of their surplus corn, clothes, or meat, in order to buy hats or shoes. By a system of interchange of surplus products, a bond of union is formed between all workers. Without such interchange many useful forms of labor could not exist. Mines would not be sunk, and ships would not sail the sea.

With interchange, each producer helps all producers. Shipwrights and sailors help to provide our food; for we should not get several valuable edibles, if vessels did not bring them from abroad. The plowman helps to make clothes, and the weaver to make bread; for more clothes and more bread, for both, are produced, by each keeping to his own .work, than if the plowman tried to make his clothes, and the weaver to grow wheat, grind flour, and bake his own bread. Among savages there is but little division of labor. The result is that but little is done. The homes are mere huts, and the clothes mere skins.

LESSON XX.

A Tropical Liquid.

CAOUTCHOUC, the gum generally called india-rubber, is found in the juices of several plants. The juice of the common milkweed contains a small proportion of the gum. It is, however, only in the sap of the rubber-trees of tropical regions that caoutchouc occurs abundantly enough to be of commercial importance.

The Spanish historian, Herrera, who was with Columbus on his second voyage to America, says that the Carib Indians of Hayti played games with a bounding ball made from the gum of a tree. We have numerous proofs that the Aztecs of Mexico wore a kind of moccasin made of rubber. After it was discovered in 1770, that lead-pencil marks could be rubbed out with caoutchouc, this substance was given its common name, india-rubber.

To obtain the gum, incisions are made in the trunks of the trees. In a few hours the sap which flows out fills clay basins placed to receive it. Various methods are used to solidify the sap, which, when fresh, bears a close resemblance to milk. In Brazil fires are employed to dry the sap poured on clay dishes, but in Central America it is thickened by means of the juice of the bejuca vine. A good tree will yield about twenty gallons in a season, a gallon producing about two pounds of caoutchouc. Para rubber is the best. Africa, India, Mexico, Central America, and tropical South America export the gum.

Frozen caoutchouc is inelastic but not brittle. If ordinary rubber is suddenly stretched seven or eight times its original length, it grows warm, and, if kept outstretched for several weeks, it appears to lose the greater part of its elasticity.

Rubber cannot be dissolved in water or alcohol, but is readily soluble in chloroform, naphtha, petroleum, oil of turpentine, and several other liquids.

When heated to six hundred degrees, caoutchouc volatilizes, and yields a fluid that has the extraordinary property of being capable of completely dissolving caoutchouc, and has also great solvent power over other substances.

To purify the gum, it is boiled for some time in order to soften it and to remove the twigs and earthy particles mixed with it. Then the gum is put into machines which grind it into bits. A stream of water flowing over it washes away all impurities. Afterwards the rubber is rolled out into thin sheets, and hung up in hot rooms to dry. Or, after cleansing, it is kneaded by heavy rollers, a process finally furnishing a block of rubber from which all air-holes have disappeared. This rubber is cut under water by strong knives. From disks thus made, rubber bands are cut by circular machine shears.

Round, elastic threads are prepared from rubber that has been dissolved in bisulphide of carbon. The pulp formed is forced through small, round apertures in a cone-shaped iron vessel. The threads thus produced are received on an endless band of velvet, and ultimately on a web of cloth about six hundred yards long. While the threads are in transit on this cloth, a period of about ten minutes, the bisulphide of carbon evaporates, leaving the rubber. A pound of rubber will make about nine thousand feet of thread.

As soon as the threads are thoroughly dried, they are wound on bobbins, and, in winding, are stretched as much as possible in order to deprive them, for the time being, of their elasticity. When elastic ribbon is to be woven, the threads are reeled off, and laid as warp in a loom. The weft is usually silk or cotton. After the weaving has been finished, a hot iron is passed over the ribbon, and the rubber immediately regains its elastic power.

To make waterproof clothing, caoutchouc is dissolved in bisulphide of carbon, other ingredients being added according to the nature of the material to be coated with the rubber. Machines spread the pasty compound on the cloth. Sometimes it is desired to have the cloth air-proof, as well as waterproof, and in that case as many as twelve coats are spread, but so thin is each coat that the twelve thicknesses form only one ninety-sixth part of an inch.

Rain-coats were first made by Charles MacIntosh, a Scotch chemist. He placed the gum between two layers of worsted; but in hot weather the rubber softened, and came through the cloth, rendering the garments too unsightly to be worn. At the date of the production of the early "macintoshes," 1823, the secret of hardening the gum had not been found out.

The remarkable change which caoutchouc undergoes when mixed with sulphur and heated, was in 1839 first discovered by Charles Goodyear, an American. In the previous year he had learned from Nathaniel Hayward that sulphur would dry gum-elastic. Goodyear made some articles of sulphur-mixed gum, but they all softened in a short time. One day, while experimenting with a piece of this rubber, he accidentally brought it in contact with a red-hot stove-lid. The rubber charred. He inferred that if he could stop the hardening at the right degree, the gum would remain elastic, yet would not be sticky. A trial soon proved that his inference was correct, and his great discovery was established.

As the rubber, though mixed with sulphur, had softened in a hot sun, no one acquainted with this fact would have thought of applying heat to the same rubber in order to harden it. To-day there are various methods of preparing caoutchouc, but they are all termed vulcanizing. Pure caoutchouc is very little used in the industrial arts, but vulcanized rubber is consumed to an enormous extent.

To vulcanize caoutchouc, it is first torn into shreds by machinery, and then washed. If horn-like rubber is wanted, the ground-up raw material has mixed with it about one-third of its weight of sulphur; and it is then exposed for several hours to a high degree of heat. The originator of this method of treating caoutchouc was Austin Day of Connecticut.

To produce the softer and more elastic kind of rubber, less heat and a much smaller proportion of sulphur are required. Besides sulphur, there are added, for special purposes, other substances — lead, tar, lime, rosin and lampblack are some of the more common ones.

Vulcanizing increases the elasticity of the caoutchouc, prevents cold from hardening it, and keeps it from softening except at a very high heat. Thousands of different articles are made from rubber. Perhaps the manufacture of boots and shoes is the most extensive branch of the rubber industry.

It is noticeable that of even so little used a material as rubber thread three thousand pounds a day are turned out by one New Jersey firm. Hard-rubber articles are shaped by molding, carving, and other processes. It is not small articles merely that are made from the horn-like kind of rubber. From it there have been fashioned tables, bureaus, arm-chairs, tiles, rails for railroad tracks, and flagstones for sidewalks. Massachusetts, Rhode Island, Connecticut, New York, and New Jersey are the States engaged extensively in rubber manufacturing.

LESSON XXI.

Saving is Earning.

To every producer, division of labor and exchange of products are benefits because they add to his wealth, while they develop his cleverness and foresight to see a change of fashion, so as to adapt his work to it and to avoid loss. To the whole of mankind, division of labor and commerce are benefits because the advantages that result therefrom are shared by all.

In the savage state there is no saving, for there is no industry. It is a state of warfare. When a savage meets another savage, both act like beasts of prey; for each one knows that the other is seeking for food, which is scarce and precious, and feels himself injured thereby.

In the nomad or pastoral state, tribes wander about, looking for pasture for their flocks and herds. These people consume all that they produce, all working alike, without division of labor, and with little or no interchange of products between themselves and other tribes; and there is no progress, either in numbers or in wealth. Their riches consist, as in the time of Abraham, of flocks, and herds, and tents, and their mode of life is the same as it was then. In a country like our own, progress shows itself in both population and wealth. The American people are thirteen times more numerous than they were in the time of the Revolution, and are supplied with more than twentyfold the comforts of life.

If old people have not saved enough to live upon, when they are no longer able to work, they must live upon the savings of the careful, and become a burden to their friends or to the community. If we had to support only the helpless victims of accident, it would be a blessing, in which all would gladly share. We aid the thriftless, the drunken, the idle, and the criminal, not because they deserve aid, but, because we could not endure to see them suffer.

When even the worthless have become unable to help themselves, it is then of no use to blame them; all the good that we can do is to aid them. We take their children and put them to school, and teach them habits of self-help, industry, and economy, in order that they may escape the sad fate of their parents. Another name for the practice of economy is saving, the best agent in the work of gathering wealth. What could we do in our childhood, if our fathers had not prepared, beforehand, all the blessings of home, with the means of warmth, and food, and rest?

Children have no wealth of their own. Their parents supply them with food, raiment, homes, and instruction, for years, in order to make them better producers. How can the young form the habit of saving? There are many ways open to them to practice this good habit. Saving implies taking care of useful articles. Young persons can be careful of their clothes and books, both at home and at school. They can avoid waste, mischief, and willful destruction; they can be thrifty with the gifts they receive; and, as soon as they earn wages, they can put a part by, even though, at first, their savings be small.

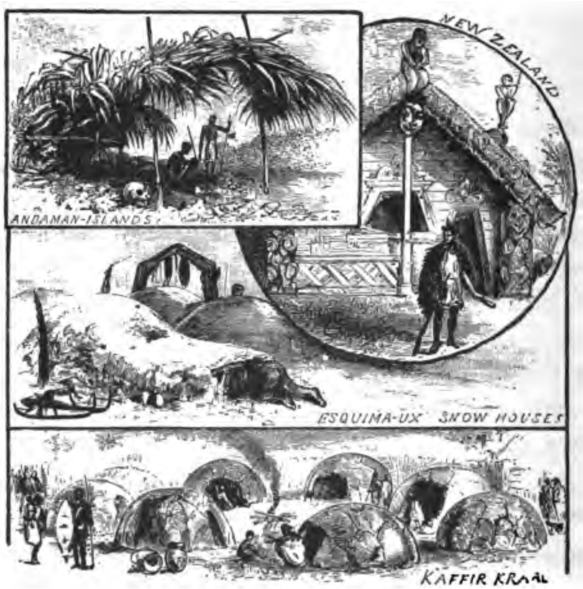
LESSON XXII.

Houses and Tools.

SHELTER of some kind from changes of the weather is, in most parts of the earth, a necessary of life, only next in importance to food and clothing. The Indians sleep in wigwams; the Arabs of the desert have tents; and the tribes in the Arctic regions dig homes underground. In the days before man had any written history, whole races burrowed in the earth or used caves for dwellings. In our own country, changes are so frequent, that we cannot be sure of the weather from day to day, and, in certain seasons, hardly from hour to hour. The means of shelter have a long history of their own. The Britons lived in huts, with walls made of wickerwork and plastered with mud, till the Romans taught them how to burn bricks and tiles, and how to build strong houses.

Roman work was very massive and lasting.

Though the villas and palaces built by the Romans have disappeared, the walls still remain as sound as ever round the cities and towns which used to be Roman camps. Part of the old London wall is now railed in and kept as a relic of Roman days; and at Chester, England, the river Dee washes against Roman stone-work with as little effect as if it were solid rock.



Different Abodes.

The Normans built great feudal castles, the ruins of which still adorn English landscapes, while their serfs dwelt in hovels, with the bare ground for flooring. Modern houses are built for health and comfort, and are far superior to the houses of our forefathers. Building materials are sought from all the three kingdoms of nature; and such a minute division of labor is carried out, that many mechanics are called upon to do work formerly falling to the lot of a single man.

Tents and Wigwams.

Old European country homes abound, the beams of which, made of chestnut and oak, are as sound as when the houses were built four or five hundred years ago. Oak, walnut, and cherry are the principal woods used for the finer wood-work in our houses. Stairs, floors, and dadoes made of these woods wear well. Modern skill enables us to multiply the uses of the walnut wood, whose beautiful grain or marking fits it for veneers, that is, thin sheets for overlaying inferior woods. Machine-saws can cut these veneers almost as thin as leaves of paper.

Cutting Timber.

When mahogany from the West Indies and Honduras, and rosewood from Brazil, were brought over to England, soon after the discovery of America, they found little favor at first, because of their hardness, which spoiled the workmen's tools. As soon as the first article of mahogany, said to be a candle-box, was made, its beauty and polish made difficulties of working of little account, and those woods took the place of walnut and oak, until scarcely a house was built without employing them, more or less, in its construction. The real excellence of walnut and oak have brought them again into favor, and the best kinds are almost as costly as their foreign rivals.

Our own country gives us the black walnut and the bird's-eye maple, whose name refers to its curious and pretty grain. From tropical America we obtain cedar and heavy woods — the first is seen in cedar pencils, and the others are used for bowls, balls, and bearings for machinery.

To furnish the timber which is of so many different kinds, and which grows in parts of the earth so distant from one another, requires much hard labor, yet all of it has for its end our means of shelter, warmth, and rest. We think of the sturdy forester who plies his sharp ax on the standing tree, the distant hewer who shapes the logs, and the hardy raftsman who guides the log-raft home.

The timber is raw material to be used in new industries. Observe a carpenter at work. Notice his tools to save time and toil. Try to understand the skill spent in suiting these tools to the ends in view. Examine, for example, a common hand-saw.

Carpenter's Shop.

It is fixed to a handle, so well contrived, that the whole force of the workman's arm impels the saw. The teeth are set all in one direction, in order to get the full effect of the thrust across the wood, and to save their edges in the return. The blade tapers from the handle to the point, for the purpose of increasing the firmness of the stroke in the descent, and of decreasing the friction when the saw is drawn back.

There are thought and design in these clever devices. To the men who contrived them, belong the merit, both of saving the laborers of every age after them from hard toil and of giving them new and higher powers of production. How it should encourage the young, who wish to perform their parts well, to learn that every useful invention is the parent of many others! From the hand-saw has sprung the whole series of fixed, compound, and circular saws, all of which were unknown before the present century. Frameworks of saws, set close for veneers or wide apart for planks, and moved by steam, now cut several logs of timber at a time; band-saws, or flexible saws, are made to follow the most delicate tracings of fretwork; and circular saws are used that cut hard wood as readily as if it were soap.

A carpenter's tool-chest contains many tools, the purpose, shape, and making of which have employed many minds, seeking to change the drudgery of rude toil into the pleasure of skilled labor. It is the great aim of the good apprentice to buy a chest of tools to call his own; and it is his pride, when he grows into a journeyman, to keep them bright and sharp and in the best condition for use. "A bad workman complains of his tools." Who can reckon how much fatigue has been saved, and how great is the sum of comfort we enjoy in our homes, because clever men lived before us, and gave their minds to tool-making? Can we strive too hard to gain knowledge?

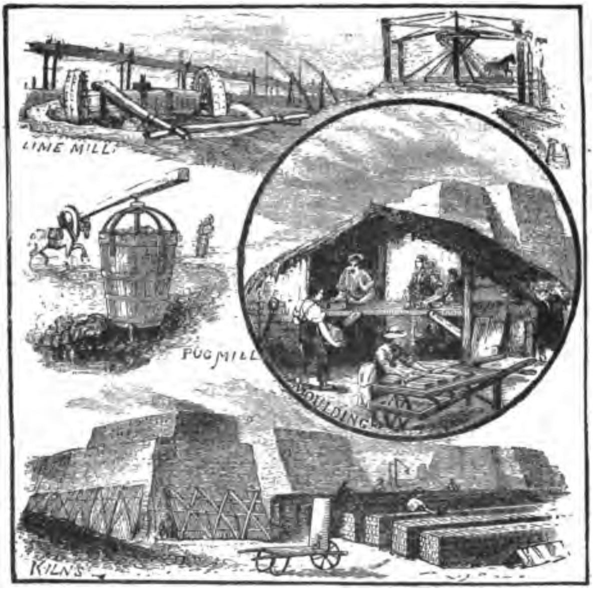
The hand-hammer has grown into the steam-hammer, known from its inventor, as the Nasmyth hammer, whose mighty force can make the earth quiver, yet which, on the mere turning of a tap, becomes gentle enough to crack a walnut without breaking the kernel. Self-acting machines, which work easily by the power of steam, drill, bore, cut, and plane iron and other metals, as if they were wood. It is a wonderful sight in our large machine-shops, our railroad works, and naval yards, to see these grand machines working as though they had life. Wherever large quantities of wood-work or metal-work are wanted, manual labor gives way to steam machinery.

LESSON XXIII.

Baking Clay.

BRICKS, as a material for building, are of old date. Molded by hand, of unburned clay, they remain in the pyramids of Egypt, the ruins of Babylon and Nineveh, and the forgotten cities of

Mexico, as records of mighty empires long since passed away. The soundness of these bricks is due to the dryness of the regions where they were used, more than to the nature of the clay of which they were made. In our climate such a material would absorb moisture and soon perish, indeed would from the first be unfit for building.



A Brickyard.

Bricks of baked clay were used by the Romans in their walls and camps, and remain in many parts of England to this day, examples of honest and durable work. Bricks were, nevertheless, not much used in England until the reign of Elizabeth, when they began to supersede wood and plaster. Fine specimens of red brick-work remain to illustrate the building attainments of that time.

The definition of a brick is that it is a mass of clay, sand, and *breeze*, or cinder ash, well pounded together, and then molded by hand in a box nine inches long, four inches and a half broad, and two inches and a half thick, sometimes having a hollow groove on one of the broad surfaces, the mass being dried in the air, and afterwards burned in a clamp, or baked in a kiln.

The shape and the size were fixed by law, when bricks were subject to a tax or excise duty. Few attempts to improve the design have been made, though the tax has been removed for many years past. Brickmaking is a long process. The clay is turned over in the winter and left to break up by the frost in order the more readily to blend with the fine ashes, or breeze, added in the following spring and summer, in the proportion of one-fifth of breeze to four-fifths of clay.

The mass is watered down and well mixed, when it is ready for the mill, in which strong iron teeth, worked by steam-power, masticate it to a pulp. It flows out at the bottom, and the clay is passed on, as wanted, to the brickmaking shed, where a "feeder" waits to receive it. The feeder takes just about enough for a brick, works it up and sands it, and passes it on to the molder, who sands the box-mold, and, with rapid skill, presses in the clay, removing any surplus with the sweep of a stick, which he keeps ready in water.

He then lays the soft mass on a pallet board till a barrowfull is finished. Load by load, they are wheeled away to the "off-bearer," who takes the new bricks between two boards, and places them, one by one in double rows in the brick-fields for drying. A brick-field is crossed by low walls of moist bricks, with lanes between, the bricks being protected from rain and snow-storms by layers of straw.

The kiln, for baking or burning the bricks, requires judgment in managing. It is either open or closed. In the first case, the clamp of bricks is built round it, and the fire is internal. In the second case, it becomes an oven, in which the bricks are baked in the same way as pottery and bread. If the fire proves too fierce, the bricks run into one another, and a mass of clinkers is the result; if too feeble, they turn out soft. To meet the prevailing winds, the flues of a clamp are put on the proper sides.

Necessity has been the mother of invention in regard to bricks. Railroad bridges, huge factories, sewer drainage, embankments, and city houses have called for bricks by hundreds of millions, numbers which could not be produced by hand labor. Many new plans have been tried to temper the clay, as well as to mold and to burn the bricks; and the bulk of the supply is now the output of brickmaking machines, although more hand-made bricks are produced than before.

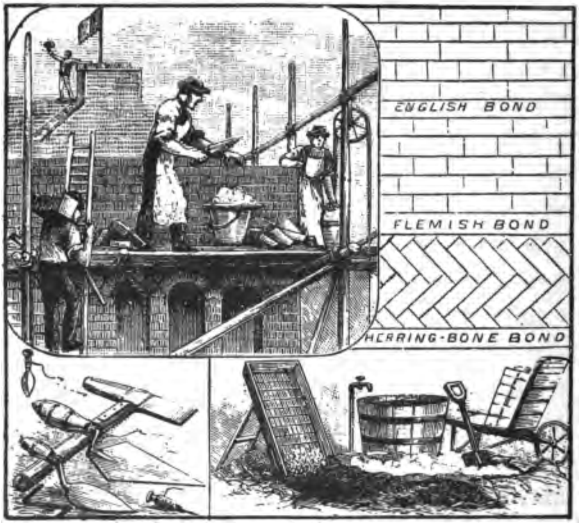
Bricks are also often formed of any common soil, which by immense compression is made dense and solid and at once baked. All mixing and drying, with their months of delay, are saved, and such bricks are delivered by the machine, at the rate of thirty to forty a minute, ready at once for firing in the kiln. Fancy a "molder" working at such a rate!

Machinery has reduced the making of bricks to half its former cost, and has thereby led to many more being made. The first brick-mills were poor affairs, though regarded as among the wonders of their age. Workmen wheeled, to a shed, dry clay and with the simple contrivances of ropes, planks, and inclined planes, it was got to the first floor, tumbled down a funnel, wherein the loose clay was compacted, by great pressure, into bricks. Such bricks were far more lasting than most of the bricks made by hand in the old way. No preparation; no water, cinder-breeze, mixing, tempering, waiting, or drying; simply clay, and that bad,—pressure and baking did the rest.

When the brick leaves the kiln, it goes to the bricklayer, who stands high in the ranks of industry, and earns good wages as a skilled workman. He is waited on by a strong laborer, who brings him the bricks in a hod, and prepares the mortar, which is a cement of lime slaked with water and mixed with sand.

The bricklayer lays each course of bricks in a bed of mortar, lengthwise and endwise in turn. He calls the lines of mortar "joints," and is careful to break or strengthen the upright joints by putting the bricks across, in such a way that no two upright joints shall come in one unbroken line. There are several modes of breaking the joints, as may be seen by looking at the walls of any brick building.

The inquiring scholar will ask some intelligent bricklayer to explain to him the difference between an English bond, a Flemish bond, a garden-wall bond, and a herring-bone bond. He will learn that the old English bond is the most in favor for buildings,—that is, courses of full-length bricks, or "stretchers," and then a course of end bricks, or "headers." The Flemish bond consists of alternate "stretchers" and "headers" in every course. The garden-wall bond is composed of three stretchers to one header. The herring-bone bond is employed for ornamental work, where the joints lie across or slope. Sometimes the walls need to be only very slight, and then the bricks are bedded "on edge."



Bricklaying.

When walls have to be built, the space is first measured out and the sort of bond settled. If windows or doors interfere with the regular setting of the bricks, the bond is varied by putting smaller pieces in the course; but these must be neat and uniform, and not destroy the character of the work. The bond is aided by a groove or hollow on the upper face of the brick, the purpose of this groove being to take extra mortar for a firmer hold. In order to give finish to a wall, the joints are sometimes pointed, or overlaid with a fine firm cement which quickly hardens. A narrow band of darker cement is often added, to give effect to the pointing.

The walls of a house are built according to settled rules as to thickness, from half a brick to two bricks and a half thick, and very seldom more than four bricks even in the largest public buildings. Three bricks, well bonded, is thought heavy work; but the piers to support railway arches, or those for the flood-gates of a dock, are masses of masonry, solid as a rock, and of great thickness. If a careless workman gets the joints in line, the foreman makes him pull his work to pieces and do it over again without extra pay.

LESSON XXIV.

Treasures of Stone.

QUARRYING, like mining, is an art which requires great skill. There are two main divisions of rocks, the igneous or fire-formed rocks, and the aqueous or water-formed rocks. Each rock has its own mode of working, modified by its position and depth underground. Granites and kindred rocks are fire-formed. They have pierced the crust of the earth in veins; when molten, they have risen in mountain peaks, flowed over the surface, like the lava streams of volcanoes, and have cooled down into rocks which, when they weather or crumble, form very fertile soils.

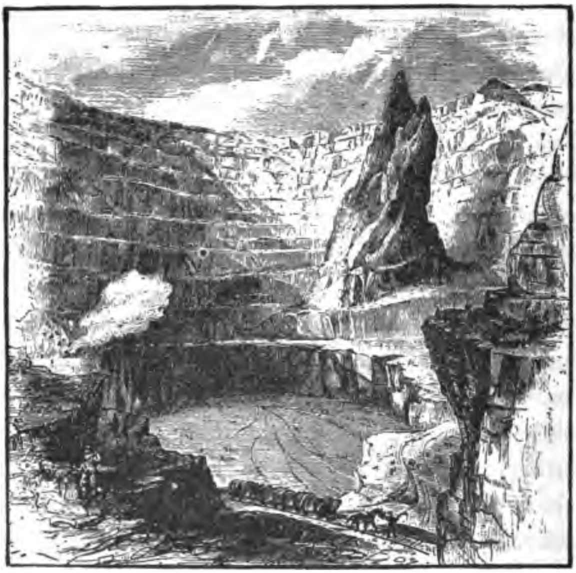
The presence of a few colored substances gives the rock a speckled aspect. According as these substances combine and their proportions vary, granites are white, red, brown, or gray. It often happens that one of the materials which make up the composition of granite is absent, still further increasing the varieties of this valuable building-stone. Whole mountain ranges are composed of granite. A city in Scotland, Aberdeen, is built almost entirely of this hard and durable stone. Notwithstanding the distance the material has to be brought, granite is in great request for the massive masonry of bridges and docks.

Sandstones and limestones are aqueous or water-formed rocks; the soft ooze or sediment left, in the course of ages, at the bottom of the sea, and, by upheaval, converted into dry land. On account of their slow formation, aqueous rocks lie in layers, or beds, sometimes unmoved from their first horizontal level, sometimes tilted to an upright position.

Good building-stone may underlie poor and worthless beds, which must, of course, be removed before the valuable stone can be quarried out. Elsewhere the quarryman may be obliged to scale rocky heights to secure large blocks of stone. Our own country is favored with richly varied treasures of both fire-formed and water-formed building-stones. We have rare and choice veined marbles for decoration, the hardest grits for grinding, granites for our bridges and heavy street traffic, hard rocks for polished shafts, and sandstone for house building.

The hardest and most compact building-stones are, as a rule, the deepest-bedded, as we might expect from the weight and pressure of the masses of rock lying above. The granites, which are the hardest rocks, lie under all the rest. Thus, also, the beautiful hard marble of Greece and

Italy, resembling loaf-sugar in its close crystalline grain, is the oldest of the marbles. Red sandstones and mountain limestone are deep-laid among the older rocks, while no building-stones of very great importance lie among the rocks which have been formed in more recent times.



A Quarry.

There are two modes of loosening the blocks of stone: 1st, blasting; 2d, splitting by wedges. Immense masses may be removed by gunpowder, gun-cotton, dynamite, and other explosives ; but the waste in squaring the rough blocks causes the second mode to be chosen for careful work.

The way that wedges rend stone is easily understood. All stratified rocks split in certain directions more readily than in others, tending to form flags or slabs of stone. These directions in which the rock tends to split are called its planes of cleavage, and they may be traced to the earliest history of the rock. Beds of sediment, like the mud banks of a river, the shoals of an estuary, and the sands of the seashore, receive at every flow of the tide a thin deposit of solid matter, suspended till then in the water; and this deposit, exposed to the sun and air, dries at every ebb.

These alternations of ebb and flow may last for ages, but every tide will have left its impress and record in a plane of cleavage over which time has no power. Even in the soft ooze of the ocean bed, the least change in the character of the deposit would imprint itself in signs which would be read in planes of cleavage, when the mud, through the agency of heat and pressure, had become solid rock, suitable to be riven into blocks for building.

To compare great things with small, the law of rock cleavage is illustrated in the making of pastry of the kind called puff crust. As the paste, under the rolling-pin, is over and over again thinned out upon the board, butter is as often spread upon the paste, which is again doubled and rolled. Now, however great and repeated the pressure of the rolling-pin on the paste, there will be, after baking, a flake of crust, representing a line of cleavage for every spreading of butter and folding of dough. In some rocks the planes are so numerous that the mineral forms very thin leaves; and in the example of clay-slate for roofing, the process of splitting is proceeded with till the slates are reduced to mere flakes. Cleavage gives to roofing-slate its commercial value.

To the quarryman the splitting is all important. He inserts into the line of cleavage a series of iron wedges, some few inches asunder, along the full length of the block of stone he has marked for moving. He then cuts cross-channels in the breadth of the block, both to prevent the cleaving from going too far, and in order to plant a fresh set of wedges. Repeated blows of the mallet drive the wedges in, and the block finally splits off. In hard rocks, where the quarryman cannot avail himself of the cleavage, he marks out his block, and drills "pool-holes" along the lines traced for the insertion of his wedges.

In these operations he is assisted by the quantity of quarry water absorbed by the stone. However dense the rock, it is, as a general rule, true that the deepest-seated rock is the most saturated with moisture; from which fact we infer, that the rain, which soaks into the earth's surface, descends to depths to which we can place no fixed limits; and that, in the next place, few rocks offer complete obstruction to the passage of water. This quarry water obliges the laborers to stack the blocks of stone till they are dried and seasoned by the sun.

Massive wagons and stout horses convey the stone from the quarry, by road to its destination, if not too far; or the railroad takes it in charge for quick dispatch; or the canal-boat, where the saving of the cost of freight is of more account than the saving of time. By any route it finally reaches the worker in stone, who further dresses, shapes, faces, fits, and adapts it, as required, for the main walls, the pillars, causeways, steps, staircases, doorways, arches, window-sills, fireplaces, mantel-shelves, hearths, sinks, street-paving, or for pure ornament.

According to the skill and genius of the worker, he is called a stone-mason or a marble-cutter, a stone-carver or decorative mason, a statuary-mason, or a sculptor. In all these divisions of labor we observe that the same industrial laws reign that regulate the production of the food we eat and the clothes we wear. We trace the same desire to adapt the means to the end in view. We note the same effort to acquire the skill which can come only by practice.

LESSON XXV.

Glass.

WE have no record, no evidence of the date when the art of making glass was discovered. An old story, repeated by the celebrated Roman writer, Pliny, is that some Phœnician traders were driven by a storm ashore near the mouth of the river Helus. To hold the kettle containing the food they were about to boil, they placed some lumps of natron on the sea-beach; the natron and sand, fused together by the heat of the fire, became a transparent and glassy substance. Chance probably did lead to the original production of glass. We must, however, be contented with learning that the art of glass-making is to be traced to a very remote antiquity.

Egypt supplies us with the first certain proofs of glass manufacture, as she furnishes us with the first positive evidences of the practice of many other arts. Glass bottles are represented on monuments more than 4,000 years old. On the tombs near the village of Beni-Hassan, there are paintings, just as ancient, that show the process itself of glass-making.

A glass bead has been found bearing the name of a queen who reigned 1500 years before the commencement of the Christian era. Greek writers describe obelisks, 60 feet high, made of green glass. Beads were among the first glass products, and were used for barter with the

Glass-Making.

negroes of Africa and the savage races of western Europe. A bead, discovered in a very ancient Celtic grave in England, was analyzed by a committee of distinguished chemists, and ascertained to be composed mostly of silica, potash, soda, and oxide of copper.

The art of glass-working had made great progress in Rome before the reign of the emperor Augustus. The Romans knew how to stain glass, to blow it, to work it on a lathe, and to engrave it. The finest example of their art in glass which has come down to us is the famous Portland vase, now in the British Museum. It was found in an old Roman burial vault. The vase is about ten inches high, has two handles, is made of transparent dark-blue glass, coated with a layer of white glass, which has been so carved down to the blue basis as to form groups of human figures of the most admirably artistic execution. The Roman artist not only combined differently colored kinds of glass, but also often imbedded gold leaf in the glass in order to gain further variety in the ornamenting of his productions.

A knowledge of the processes of making both plain and colored glass was diffused through Europe as early as the 12th century at least. The use of painted glass for windows began about the year 1020, and reached its greatest extent four centuries later. It must be remembered that there is a great difference between painting glass and staining it. Stained glass is produced by mixing metallic oxides with the ingredients of the glass while they are molten. The coloring materials become fluid, and pervade the substance of the glass. To paint a plate of glass the artist applies on the surface the coloring pigment, which is the oxide of some metal, and which is durably fixed on the glass by means of a strong heat.

During the Middle Ages the chief seat of the manufacture of glass vessels and ornaments of the greatest beauty was Venice. Venetian glass has long held a world-wide renown. It is of extreme thinness, being nearly always blown, and there is an endless variety to be admired in the shapes and in the application of color. The lightness and strength of Venetian glass are due to the fact that it is free from lead, unlike our modern flint glass. Its lightness enabled the makers to give us the marvels of delicacy and beauty which we wonder at to-day. Constant care was taken to keep the processes of the manufacture secret, and we are ignorant of many of the details which belonged to it. No modern attempt at imitating some of the cups has been successful.

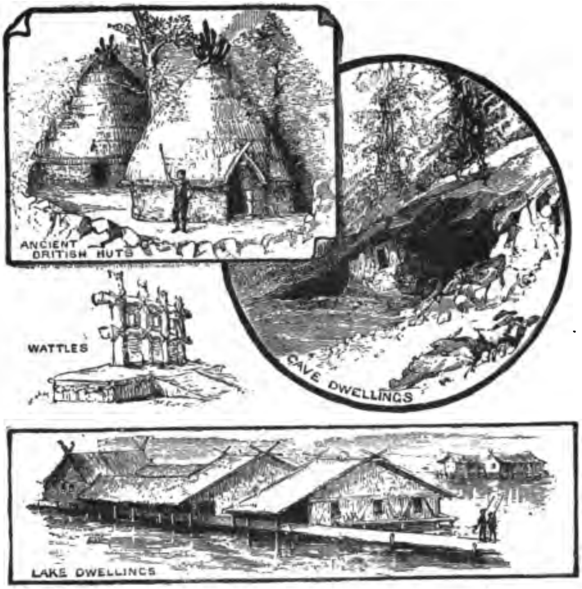
To make plate glass the molten material is poured on an iron table over which a heavy iron roller then passes several times, reducing the "metal" to a uniform thinness. The sheet of glass is then ground and polished. Window glass of a cheaper grade is made from cylinders of glass, which have been formed by rapidly rotating, at the end of the glass-blower's rod, lumps of the molten substance. These cylinders are cut and flattened out. Flint glass is blown. After being shaped by wooden tools into the desired forms, grinding and engraving finish the ware for the market. The cheaper grades of glass table-ware are molded by machine presses.

LESSON XXVI.

Hints from History.

THE progress of the art of building can be traced back to its origin by graded records left upon the earth long before written history was known. The relics of pre-historic man are arranged in three eras, according to their succession in time. 1st, The Age of Stone; 2d, The Age of Bronze; 3d, The Age of Iron. These names refer to weapons. Human dwellings, in the earliest of the early times, were natural caves. The cave-dwellers have left in their abodes relics in the shape of "celts" or axes of flint, both tools and weapons, together with the bones of animals devoured for food.

From these few and simple facts we infer a history of indefinite duration. Cave-dwellings impressed upon human habitations a style which has lasted since the ages of poetry and fable. The chief feature of the first architecture is its vastness. Hindu fanes excavated in the solid rock, on the island of Elephanta and elsewhere,



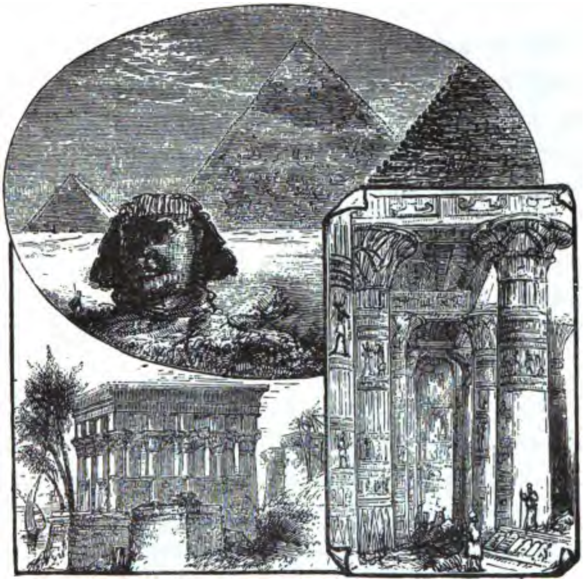
Ancient Dwellings.

and similar works discovered in Central America, are among the most gigantic temples ever constructed by man. At the next advance in the building art, we meet with those huge edifices of rough masonry which were ancient in Homer's day, and which fable says were built by a one-eyed race of giants, who lived in Sicily and other places where such heavy buildings are found.

Of a like fabulous origin are the so-called Druid remains, inspiring awe from their massiveness and age, at Stonehenge, Dartmoor, England. The lean-to walls, the great thickness of the roofs, and the cavernous interiors of these structures, recall the cave-dwellings, which must have impressed the minds of their architects more than the means of easy transit of materials. The enormous blocks must have been brought from a distance by the sheer bodily exertion of numerous laborers.

> "Temples, towers, and piles stupendous,
> Of which the very ruins are tremendous,"

strew the sands of Egypt, memorable records of the next past stage of architecture. In that land building was done on a colossal scale: there remain enormous figures of the gods, curious animals, carved out of immense blocks of stone brought from afar; columns and "needles" — single granite pieces, exceeding seventy feet in height, of which the obelisk in Central Park, New York, is a famous example; palaces on the grandest scale; and pyramids of vast dimensions, built for royal tombs, to keep in mind a race of rulers, whose bones had moldered away, and whose names had been lost, long before written history began.



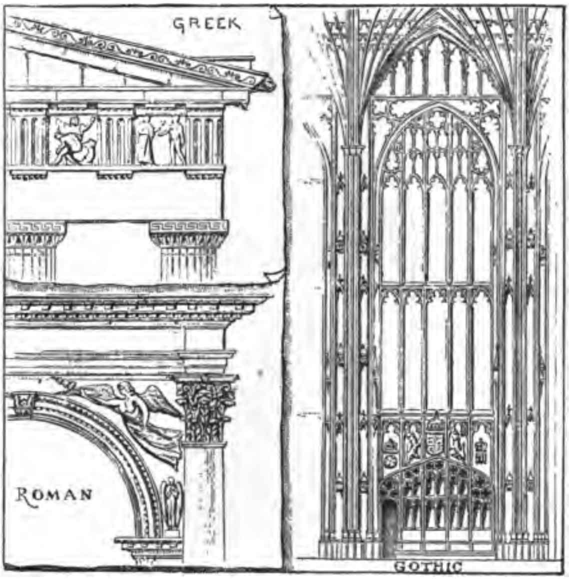
Egyptian Architecture.

Such is the littleness of greatness. So passes away the glory of the world. No matter how great man may be in his day and generation, as time rolls on his importance dies away. He may have commanded armies, he may have conquered empires, yet as years fleet by he is at last forgotten. Other great men arise; and the more these claim attention, the less thought is given to those who lived before.

But we are forced to admire some of the works which man has left behind him. We have nothing to compare in size with the pyramids of Egypt. The ruins of Babylon and Nineveh, though now half buried in the sands of the desert, show that the buildings of those great cities were superior to ours. The edifices of the ancient Greeks and Romans, who came afterwards, were quite as fine and solid as the largest of any similar works of to-day.

On the other hand, the inventions of to-day will certainly last longer than those of the past. Printing, the steam-engine, the electric telegraph, the telephone, the submarine cable, the railroad train, and the ocean-going steamer, have each done more good, and will certainly aid humanity's upward progress *more* than any material invention of the mighty minds of old.

We cannot study the history of building without being struck by the extreme and strange contrasts between the earliest rude forms of human dwellings and the homes of rich people of the present day. The distance from the first retreats in caves and groves to our modern palatial city residences is as far as the poles asunder. But the wretched poor who huddle together in crowded rooms for the sake of warmth, and thereby breathe foul air



Different Styles of Architecture.

which breeds disease, are worse off than our savage Indian tribes living in wigwams.

Even yet our finest houses are far from perfect. Building is a wide province for those youths who feel inspired to ennoble their lives by good service to mankind. House and home are so linked in with our health, ease, comfort, and happiness, that architecture, in both theory and practice, calls for the thought of the philosopher, the wisdom of the statesman, and the highest skill of the mechanic. Health, convenience, and comfort, are the chief things to be considered in the choice of a house, the place in which we pass so large a part of our lives — the whole of the night-time, and some hours at least of every day.

House Finishers.

Health cannot be secured, unless the site is dry, the drainage perfect, and the ventilation good. Convenience in a house depends upon the size and arrangement of the rooms, the quality of the gas and water supply, and the location of the building. Home comfort is impossible in an unhealthful inconvenient house. Good temper and family love are sorely tried amid discomfort. The more comfortable the rooms, and the cleaner and better furnished they are, the more likely are the men,

House Builders.

women, and children, who live in them, to be happy.

With the increase of intelligence from the spread of education, the laws of health in relation to house-building will be better understood.

The day will arrive, when the fumes of the kitchen will be carried out into the open air, and no longer allowed to fill the rest of the house. The products of combustion from our gas-jets will be conveyed from our sitting-rooms, rather than allowed to poison the atmosphere we breathe. Water will be laid on without stint. Ventilation will be arranged to give us fresh air all the time, and baths will be provided in every home. Foundations will not settle on "made" ground, and walls will be proof against damp. Windows and doors will keep out draughts, and the woodwork will not warp, crack, and gape. Well-built houses influence for good the families who live in them, by fostering health, comfort, and placid temper, thereby insuring greater social happiness and longer duration of life.

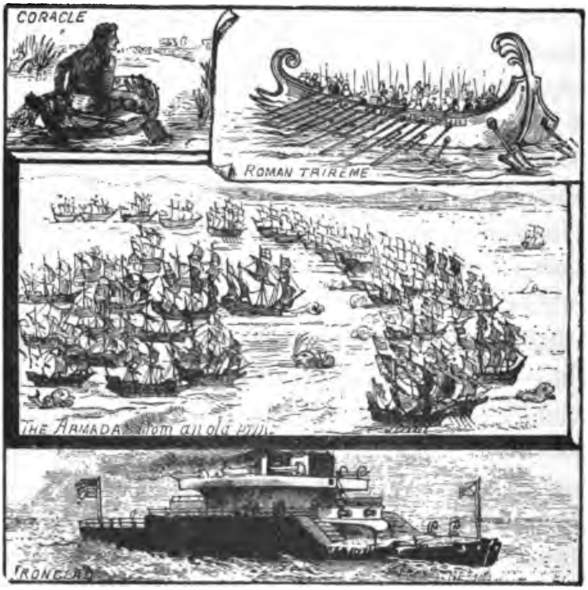
LESSON XXVII.

Ships.

MAN'S first water vehicle was doubtless a raft — a few logs tied together with vines, roots, or strips of raw-hide. The dug-out canoe, the earliest attempt at a vessel, was suggested probably by a floating shell. Then, perhaps, the hollowed trunk covered with bark may have been the means of furnishing some intelligent savage with the hint to use the bark alone, and thus to set afloat the first real canoe.

Egypt shows us the oldest representation of a ship — one that must have been built before 3000 B.C. It had a mast consisting of two pieces, set apart at the deck, but joined at the top, resembling an inverted V. The vessel was navigated by one large sail, aided by twenty-two oars, pulled by slaves. Naval battles on a large scale must have been common even in the first epoch of shipbuilding. The tombs of several Pharaohs have cut in the granite walls records of victories over the fleets of nations long dead and forgotten.

The further development of the ship belongs to the Phœnicians. At an early date they constructed merchant vessels capable of carrying large cargoes, and having three banks of oars. By placing one set of rowers above another, they doubled the speed of the vessel, without being obliged to increase its length.



Vessels of Different Times.

Still larger ships were built by the Greeks. Their largest vessel, constructed about 280 B.C., had sixteen banks of oars, and required a crew of three thousand men. It is not quite clear how a vessel of several banks of oars was navigated.

We know that the lowest oarsmen used the shortest oars, and that the longer oars of the upper banks were weighted with lead, and would balance at the rowlocks. Still no satisfactory explanation has been given of the way in which so many men could work freely or without interfering with one another.

Roman warships had towers fore and aft. From their tops darts, rocks, fireballs — in short, missiles of all kinds could be hurled at hostile crews. Heavy iron beaks were attached to the prows. In a sea-fight the main object of a Roman naval commander was to stave in the side of the enemy's vessel.

Fifty years ago a shipwright was a skilled artisan. But the introduction of the steam-engine changed all his methods. The models which suited so well for ships were found ill-adapted to the paddle-wheel or the screw-propeller.

Attempts to move ships by steam-power were made long before a steam-engine to work on land was designed. The first successful steamer, the "Clermont," was constructed by Robert Fulton, an American. She ran on a trial trip from New York to Albany in 1807. Like every other great inventor, Fulton had to overcome ignorance, ridicule, stupidity, the opposition of enemies, and the coldness of friends. He himself has left on record the fact that, after the "Clermont" had arrived at Albany, several of the passengers announced their intention of going back by stage to New York, because they were certain that the steamer could not make the return trip without sails!

But Fulton's success was recognized by others, and in a few years steamboats were familiar sights on the Great Lakes and on all our large navigable rivers. The rapid growth of our Central States, the West of half a century ago, is due partly to the "paddle-wheelers." Mere landing-places on the banks of the Ohio and the Mississippi grew quickly into cities under the stimulus of regular steam communication.

Various machines for utilizing steam to move vessels were tried by Fulton. He experimented with the screw-propeller, but finally decided in favor of paddle-wheels. They were universally used for several years. Many war-steamers were built with paddle-wheels, but the advantages of the propeller were at length perceived. Cannon-shot could easily destroy the wheels, and their boxes took up too much of the deck space, and obstructed manœuvering at drill. The U. S. S. Princeton was the first war-steamer built that used the propeller. The one she employed was more powerful than any previous form of the machine, and was designed by John Ericsson, the distinguished Swedish-American engineer, to whom the United States owes the famous Monitor.

Sailing-vessels have disappeared from the navy. Wooden war-steamers will soon be unknown. The modern battle-ship is a floating castle, protected by heavy armor, and filled with machinery. Indeed, without machines the cruiser of to-day could neither move, nor fire her guns, nor even be habitable for her crew; for the breathing air below the deck is driven down by fans revolved by steam.

The largest cannon of our Revolutionary days, the 32-pounder, has been displaced by the 111-ton rifled gun, which throws to a distance of ten miles a projectile weighing eighteen hundred pounds, and burns nine hundred pounds of gunpowder at every discharge. The destructive power of such a gun is fearful. At one trial the projectile went through twenty inches of steel, then through eight inches of iron, next tore its way through twenty feet of oak timber, five feet of solid granite, eleven feet of cement wall, and finally buried itself three feet deep in a brick wall!

The first battle between ironclads was fought in our Civil War. At Norfolk, Va., the Confederates removed the masts of a 50-gun ship, the Merrimac, built up over her decks and down the sides to below the water-line a ball-proof covering formed of railroad-iron plates. These met at the top, making a roof like that of a house. She was armed with five heavy cannons of English make.

On March 8, 1862, she steamed out to attack the blockading Union squadron of wooden sailing-vessels. The first ship she engaged in battle was the old Cumberland. The heavy iron ram on the Merrimac's bow easily stove a large aperture in the Cumberland's side. The Union vessel filled rapidly and sank. But, to the eternal honor of her gallant crew, she went down with flying colors. Even when she careened to sink into her watery grave, her sailors stood heroically to their guns, and fired a last broadside at the ironclad. The cannon-balls rattled off her armor as harmlessly as hailstones. The next ship attacked was the Congress. She was obliged to surrender. Darkness coming on, the Merrimac returned in triumph to Norfolk.

The telegraph flashed the news of her victory through the length and breadth of the land. Consternation seized on the dwellers in the northern seaboard cities. What was there to prevent the iron monster from steaming into the harbors of Philadelphia, New York, and Boston, and destroying those cities at her leisure?

Next morning the Merrimac, amid the tumultuous cheers of the citizens of Norfolk, moved down Hampton Roads, towards Fortress Monroe, to sink the rest of the Federal fleet. There were no cheers heard in Norfolk when she labored slowly back to her anchorage a few hours later. She was met by an antagonist she little expected to see, an ironclad that had arrived during the night — the celebrated Monitor. This vessel was smaller than the Merrimac, and carried only two guns, but she was superior in construction, thanks to the genius of her designer, Ericsson, and she was handled with much greater skill. In the naval duel that ensued, the Confederate vessel was badly worsted, and she retreated to Norfolk, never to venture out again.

About half a century ago shipbuilding in iron was a new industry. The steam-engine was being widely introduced by marine architects, and the need of some structure stronger than wood was apparent. Steel has superseded iron. Steel vessels are lighter, stronger, safer, and more durable than either iron or wooden ones. The immense ocean-steamers constructed in recent years are of steel. It makes a hull of less weight, and thereby adds to the vessel's tonnage.

The first steamer that crossed the Atlantic was the Savannah. It took her twenty-five days to make the voyage from New York to Liverpool, in 1819. At that time clipper ships could go from one of those ports to the other within twenty days. Most of the large liners now run the trip inside a week. One of the 10,000-ton steamers has recently made the voyage in five and two-thirds days. Once, five knots an hour was fast traveling; now, an eighteen-knot rate in the same time is not uncommon. A nautical knot is 6,080 feet. A land mile is 5,280 feet, being about one-sixth of its own distance less than a knot.

Five hundred and fifteen miles of the Atlantic Ocean have been plowed through in a day by one of the big passenger steamers on her way from Queenstown to New York. But this marvelous increase in the speed of sea-going vessels has not been gained without cost. Genius of the highest grade and mechanical skill and heavy capital are represented by every modern steamer.

Two million dollars is the lowest price at which a first-class, 10,000-ton steamship can be built. For one round trip between New York and Liverpool, such a vessel's outlay will amount to seventy-five thousand dollars. Coal is the most costly item in the expense account. Several of the great liners consume, each, three hundred tons of coal a day — four hundred and sixty-six pounds a minute!

LESSON XXVIII.

Our New Navy.

THE United States cruiser Chicago, built of mild steel, is a good example of a war steamer containing all the latest improvements in naval construction. She carries powerful search lights, which reveal the presence of the smallest torpedo-boat even a mile away. A complete system of fans and ventilators keeps the air between decks fresh. Her electric-light plant is the best in any vessel in the world. In addition to twelve heavy cannons she has six rapid-firing guns. These can fire, each, eighty rounds a minute, and the shot can pierce the side of any wooden vessel at a distance of two thousand yards — over a mile.

A modern war-vessel resembles, on ordinary days, a vast workshop wherein various trades are carried on. Sailors seem to have the ability to adapt themselves to several handicrafts, and to work with success at all of them. When we visit the Newark, the Charleston, the Baltimore, or any other one of our new naval ships, we shall probably notice painters and varnishers busily wielding their brushes, carpenters employed here and there doing slight repairs, tailors making canvas hoods for the steam launches, and artisans in iron will not be lacking; for we shall be surprised to see a blacksmith's shop and some stout, bare-armed men at work therein, perhaps forging a chain link or welding a railing bar.

Any one of our larger cruisers has usually on board goods enough to stock several "general" stores. Ten thousand pounds of white lead, and quantities of other painting materials in proportion, form part of the Chicago's ordinary equipment supplies. Every necessary of ship-board life, almost everything of luxury needed to make the hearts of our gallant Jack Tars happy, is to be found among the paymaster's stores. Little brass pins and big steel-bladed pocket knives, gayly colored handkerchiefs, and plain blue flannel, hats, thread, oil-cloth coats, shoes, razors, spoons, blacking-brushes, scissors, tin cups — all these articles and many others may be obtained when desired.

A table is placed aft on the gun-deck, the goods are spread out on the floor on one side of this table, and on the other side the men wishing to buy are drawn up in line. At the head of the table is seated the officer of the division. Before him is a large sheet of paper bearing the names of all the crew. As soon as each sailor's name is called, he walks around to the little heaps of stores, selects the articles he wants, receipts for them, and takes them away. There is no time wasted waiting for "cash" to return with the change!

Compared with the quarters provided for the crews of even the largest steamers, the sailors on a modern man-of-war are housed with luxury. The forecastles, the cabins in which the men slept in the old-time wooden naval vessels, were close, ill-smelling dens. If one of those brave old sea-dogs that manned the famous *Constitution*, "Old Ironsides," as she was affectionately called, the pride of our navy in her time, — if one of her heroic crew could visit any of our lately built big war-ships, he certainly would be astonished at the commodious quarters set apart for the men. What surprise would be his, if he were taken on board the Chicago, shown into an immense, well-lighted, airy room, three hundred feet long, and told that it was the steamer's forecastle!

Besides being better housed, clothed, and fed than his fellow-worker on a merchant steamship, the naval seaman has the great advantage of having several hundred dollars coming to him from the United States government, when his term of enlistment expires.

On the deck forward the men like to congregate, if the weather is fine. There, on off hours, they may be seen engaged in various unwarlike occupations. Here are some middle-aged, sturdy mariners plying the needle as deftly as so many seamstresses; near by a lad is operating a sewing-machine, and doing difficult work, we notice, for he is stitching a jacket sleeve; yonder are some men writing letters, using lead-pencils instead of pen and ink, and reclining against the sides are twenty or thirty bronzed tars, engrossed in books from the vessel's library.

No other feature of the modern war-ship's equipment so distinctly shows the superiority of to-day's naval service over the naval service of fifty years ago as the library. The men appreciate the privilege of reading good books, as is manifest by their frequent requests to the librarian to give them standard works.

But life on board a government cruiser is not all leisure time. At sunrise the boom of a cannon wakens the echoes over the water, and tells officers and crew that the labors of another day must be begun. Before the powder smoke has drifted away, the buglers are sounding the reveille, and the men are turning out.

A shrill, piercing whistle penetrates every ear. It is the boatswain's signal to pipe up hammocks. These are out of sight in a few minutes. Coffee, with bread, is then served to the sailors, and they are set at work, scouring the decks, burnishing the bright parts of the guns, and doing whatever else is needed to make the ship spotlessly clean and attractive.

At eight o'clock is the ceremony of "colors." The United States flag is run up to the masthead, the band strikes up "The Star Spangled Banner;" every soul on deck, from admiral to cabin-boy, turns his eyes on the flag, and lifts his cap in salutation. As soon as the band has ceased playing, the men are piped to breakfast. After this meal the band plays for an hour on the gun-deck. A marine band consists of twenty men, usually excellent musicians.

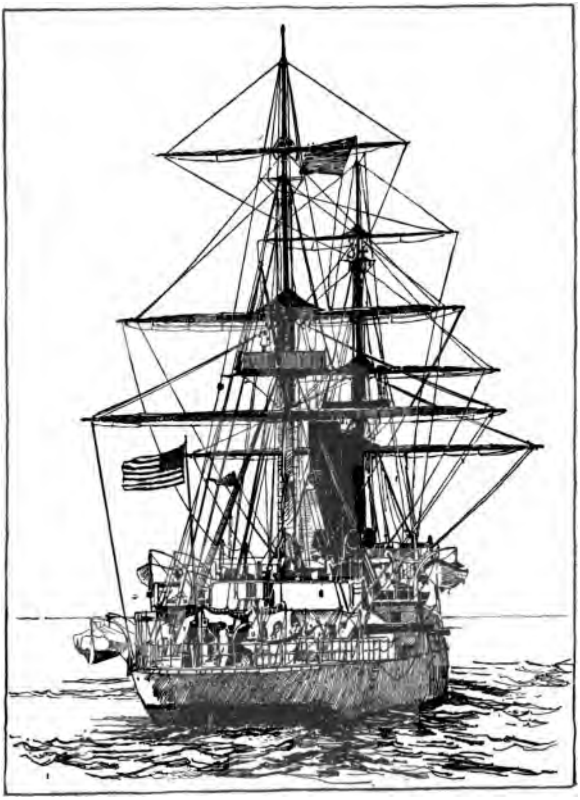
A bugle-call at half-past nine summons officers and crew to their stations for inspection. Every member of the ship's company must be present, or be accounted for to the satisfaction of the inspecting officer. Any one absent without excuse is branded as a deserter, and an order for his arrest is issued. A deserter from the military or the naval service of the United States may, unlike an ordinary criminal, be seized anywhere within the borders of this country, and be taken out of a State without the permission of its governor.

During the forenoon the crew is drilled in squads, on the spar-deck in pleasant weather, but if the day is stormy, on the gun-deck. In the afternoon cannon practice, cutlass drill, exercises with small arms, and other branches of naval tactics occupy the time. On certain days the men are exempted from drill. Five o'clock is a pleasant hour always — the men are piped down to dinner at that time!

The flag is lowered at sunset with the same formalities and tokens of respect that were shown when it was flung to the breeze in the morning. Hammocks are slung at half-past seven, and at precisely nine o'clock bang goes a gun, and the electric lights are instantly turned out. Sea-signal lanterns, one green, one red, and one white, are lighted and hung in the rigging in order to give notice of the vessel's location. Silence and darkness reign throughout the ship. Only the watch officers are awake. They must keep their lonely vigils, and guard the safety of the slumberers below.

The Boston is a protected steel cruiser of a type that has not found favor in later years with our naval constructors. She floats lower in the water than steamers built like the Philadelphia, the Chicago, the San Francisco, and others of their class. In stormy weather the Boston is apt to have her deck flooded frequently, and for that reason she is what sailors call a wet ship.

Over one-half her length amidships there is a huge box-like structure. This covers her broadside guns and the crew's quarters. The Boston is smaller than the Chicago, being only two hundred and eighty-three feet long, while the latter vessel's



The "Boston."

length from bow to stern is three hundred and thirty-four feet. The Chicago's carrying capacity, forty-five hundred tons, is over one-fourth greater than the Boston's tonnage. The speed of each is fourteen knots an hour. Notwithstanding her low build, the Boston is a serviceable ship, and would give a good account of herself in a fight.

Neither of these cruisers is what marine architects would call an armored vessel. Both steamers are, like all our new cruisers, of the class known as protected ships. Each one has a deck of steel one and a half inches thick over her engines and steering gear, and her outside steel plating is five-eighths of an inch in thickness.

But the hundreds of tons of coal on board every cruiser are so arranged as to form an effective belt of armor all around the vessel above the water line. These steamers are intended to be employed, in case of war, as commerce destroyers. They were not constructed to fight the big ironclads armed with 110-ton guns.

However, should war break out between the United States and one of the great commercial powers, Great Britain, for example, these fast steamers, armed with long-range guns, would in a few months destroy her carrying trade, thus inflicting enormous damage at but little expense to ourselves. It is certain that no mercantile nation will hereafter declare war against us, if war can be avoided.

The battle-ships now being constructed, the Maine, the Texas, the Massachusetts, the Indiana, and the Oregon, will be ironclads of heavier build. These, when afloat, will represent in our navy the fully armored fighting vessel of modern times. Each of them will carry, in addition to a number of smaller cannons, four thirteen-inch breech-loading rifles, weighing sixty and a half tons apiece, and made of forged steel throughout.

The power of a gun of this make is tremendous. Five hundred and fifty pounds of powder are required for every charge; and the projectile, eleven hundred pounds in weight, leaves the muzzle at a velocity of twenty-one hundred feet a second. These figures tell us that such a gun can smash the steel hull of even the largest trans-Atlantic steamship eight miles away!

So destructive have the means of warfare become that hereafter all conflicts between nation and nation must be short. Before attacking one another, governments will hesitate long. Certain ruin awaits one or more of the countries engaging in any deadly struggle in the future. Every new agent of death, rendering battle more terrible, may therefore be considered a promoter of peace. May our eyes behold the dawn of that day of true glory when the nations shall beat their swords into plowshares, and their spears into pruning-hooks, and shall learn war no more!

LESSON XXIX.

Goods and Chattels.

CHATTELS is a legal term employed to describe all sorts of movable goods; but the goods and chattels of a house may refer to the manifold articles which our wealth, tastes, and habits have under the name of furniture, rendered necessary to the comforts of home. The rich man gives his orders to the upholsterer, as the furnisher of his house is called, to fit up his mansion throughout with costly goods, according to the fashion of the day, or the style of former days, or of that which prevails in countries noted for good taste. Working people collect their household effects by hard effort and self-denial. Every addition they make to their furniture has its own history.

Let us marshal before us the army of workers through whom the upholsterer is able to execute an order to furnish a house. First comes the cabinetmaker, whose craft is as old as history; for couches, tables, and sideboards were as well known to the ancient world as they are to the modern.

Old Egypt, by its early system of castes, kept families from age to age at the same handicraft.

A Modern House.

The Egyptian laws required that "every cobbler should stick to his last," and that his son, grandson, and great-grandson should stick to it too. In nothing is the difference between the manners and customs of the ancient Egyptians and of Americans more striking than in this system of caste;

for in our happy country, every career is open to the poorest child, if he only has force of character enough to make his way.

The custom of caste in Egypt caused skill in workmanship to descend in the family, and it reached such excellence that the designs of their chairs and couches have never been excelled. The fine workmen of Carthage, likewise, made the term "Punic," among the Romans, to be, when applied to furniture, descriptive of the highest art, and Punic furniture was eagerly sought for by the rich citizens of Rome.

Cabinetmaking was much followed in the Middle Ages. Old cabinets of fine workmanship still remain which are examples of good taste. During the eighteenth century, as wealth increased, a desire set in for gorgeous furniture, which was overloaded with ornament and heavy gilding. A better taste now prevails, and the simple grace of old is copied by the best cabinetmakers.

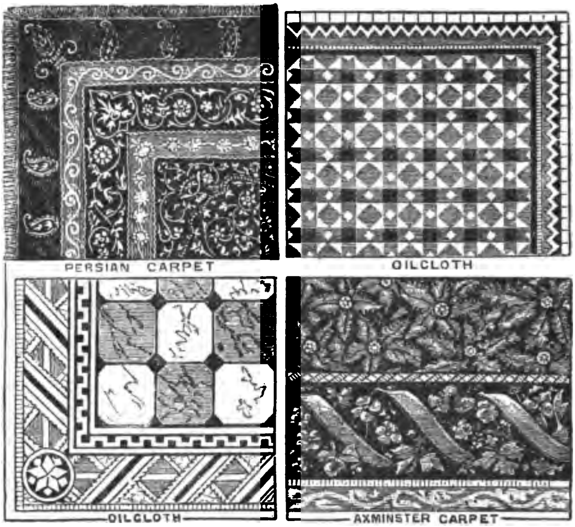
Cabinet work, once found only in the abodes of wealth, now often adorns humble homes. Tools of precision doing rapid and elegant work, the system of division of labor, and the new woods given to the art by commerce, have imparted to cabinetmaking an impulse which that art never before felt. More than two hundred kinds of wood lend their aid to the cabinetmaker. The cheapness which allows our homes to be adorned with inlaid floors and beautiful furniture is a blessing which we enjoy over our forefathers. It helps also to refine our tastes and manners.

A Modern Drawing-Room.

Tables, chairs, sideboards, bookcases, and wardrobes all form, in their manufacture, separate branches of industry, each of which is, in its turn, subdivided. The dining-table claims its own set of workmen, the round table another set, while the inlaid and fancy tables of the drawing-room are the work of artists rather than of artisans. Take the round table, for example, where the body of the table is made by one class of hands, the rosewood, mahogany, or walnut veneers are sawed by another class, and are glued on to the body of the table by a third class. Then the turner with his lathe fashions the pedestal, the woodcarver makes the claws or feet, and the polisher finishes it off.

Let us consider any portion of a house, noting what nature has done towards it, what the hands have done, and what part is due to the mind. Examine the floor. Nature has presented to us the trees of the forest. Man's arms have used on them the hatchet, the saw, and the plane. Intellect had, however, first to invent the tools, and to perfect the saws which cut the planks. Workmen could then with little trouble, and in a very short time, bring the various pieces together, and form them into an ornamental floor.

If we trace the part that brain-work takes in the regions of imagination we find that this great faculty influences the whole world for good, while the actual manual labor may be no more than that of wielding a pencil or a pen. The artist who adorns our rooms does not depend in the least upon his bodily strength, but upon his genius, for the masterpiece of painting which gladdens, elevates, and enriches mankind. The author who writes books to instruct our minds relies not upon the labor of his hands, but trusts to his imagination. The scholar, likewise, draws from deep intellectual springs the learning and wisdom which expand his mind, and enable him to aid the progress of mankind towards a higher civilization.



Floor Coverings.

Home comforts so common that we can hardly believe them to be modern, are carpets, rugs, mats, and other coverings for the floor. Their use here is scarcely more than a hundred years old. Before their introduction floors were rubbed with beeswax, and then polished with a hard broom or long-handled brush — a heavy and tiring labor, requiring much patience and strength. Carpets crept slowly into favor; first brought from the East, imitated, and then excelled in our own looms. Persia and Turkey had long enjoyed the luxury of carpets whose artistic patterns rendered them of great value.

Brussels carpets, of linen and wool, form by far the most important part of the trade. The surface consists of woolen loops, and the base, or groundwork, of strong linen threads. In Wilton carpets these loops are severed, and compose a thick soft velvet pile. Axminster carpets are the most luxurious, being tufted with colored wools; a process which consumes so much material and is so tedious, that the cost of these floor coverings is very high.

Of late years a short-pile carpet, called tapestry Brussels, cheap in make, yet of rich color, has been brought forward. The long-pile Persian and Turkey carpets, as well as the Axminster imitations of them, are made in squares, some of very large size. They are laid down loose, as in the countries where they were first made, and where the warm climate requires their frequent and easy removal. Their beauty is in their softness, and in their tasteful patterns and colors, the Oriental designs being retained.

Brussels carpets are made in widths, and are cut, stitched, and fitted to the room, the comfort of a carpet being needed here through every season of the year. They are taken up to be beaten and cleaned only at long intervals, being kept bright and free from dust by brushing with a stiff carpet-broom. The common faults of Brussels carpets are their glaring patterns and colors, which sin against nature and good taste. The artistic designs of Eastern carpets are fortunately coming more generally into fashion.

A few years ago a large number of carpet patterns and wall-paper patterns of English design were collected by the Department of Science and Art, an English institution, in a room which came to be known as the Chamber of Horrors. Huge roses, gorgeous blossoms, lions, tigers, and dogs, appeared on the carpets and rugs in shapes unknown in nature, and therefore offensive to art. Public taste has improved, and, as drawing and design are taking their place in the work of every school, faults in art tend to disappear.

LESSON XXX.

Rock Oil.

THE art of lighting in any way that deserves the name of lighting is quite modern. For centuries houses were lighted by torches of pine, placed in the walls, or held by servants. Indeed, the dark ages of history might have been so-called as appropriately from the bad lighting of street and home as from the ignorance of the people.

It would be a strange tale — the narration of all the means by which man has tried to supply the place of sunlight when the orb of day has set. Our Saxon ancestors stuck a lump of fat with a wick upon a piece of wood, and this was the only kind of candle they had for many a year. Clay lamps were for a long while common. Flaming sticks of resin, or cheaper rushlights, gleaming fitfully, were to be seen in the huts of the poor. Wax tapers illuminated the churches, but were too dear for private burning. When later hours came into fashion, tallow candles with thread wicks, which wanted snuffing, took the place of rushlights, and are spoken of as early as the time of Edward I.

Bright as our houses are with oil and gas, we can hardly imagine the dismal light of only a lifetime ago. There are people living who remember when the first gas-jet was lighted, till which event, sperm and train oil stood highest as agents of lighting. Ball-rooms blazed with pure wax candles, thousands of which were consumed on grand occasions.

Let us consider for a moment how much thought was spent on the simple act of snuffing the candle. It was quite a feat to invent a pair of spring-guard snuffers. After years of candle-snuffing it was noticed that when a candle burned at an angle instead of in an upright position, so that the head of the wick was no longer closed in by the flame, but came outside to the air, it burned away of itself. Then came plaited wicks which curved when alight, and from that time the act of snuffing the candle, the snuffers, and the office of candle-snuffers at the theaters, disappeared; as did the tinder-box and steel, and the old brimstone match, with the advent of phosphorus lights, and the handy "lucifers."

Intelligence has not been idle in the art of illumination. The chemist has met with some of his most beautiful triumphs on this field of research. He has brought into the service of lighting not only animal tallow but also vegetable oils.

A large trade with Africa has been created in palm oil. Further, the chemist found that fats of all kinds consist of a fluid oil, which can be pressed out, and a solid part called stearine or stearic acid, which is the real lighting agent. A still greater triumph has rewarded him in the discovery of mineral oil, one of the products of coal. It had not been thought possible to get oil from such a source.

A generation ago people spoke of petroleum as a new discovery. Its properties were known in Greece as far back as 490 B. C., and there is but little doubt that the oil was used at a much remoter date. In Persia it was burned in the houses of the wealthy. Large quantities were sent to distant countries, and an export tax was imposed, from which the king derived a considerable revenue. The legend of the fire which came down from Heaven, and lighted the sacred flame in the most ancient temple of the Zoroastrians, a religious sect of old Persia, probably had its origin in the accident of lightning setting a petroleum spring ablaze.

It is only within the last forty years, however, that the wonderful development of the petroleum trade has taken place. In 1847 a celebrated scientist, Dr. Young, had his attention called to a curious liquid which oozed through the crevices in the floor of a coal-mine near Alfreton, England. He distilled some of this liquid, and obtained an oil suitable for burning in lamps. This experiment led him to believe that a similar product could be obtained from the distillation of coal. He tried a kind of soft coal, and was successful in obtaining the same light-giving fluid, petroleum. In the course of a few years shale, which had been looked upon as a mineral of no value, was used in place of coal.

Thirty-two years ago oil was "struck" in Pennsylvania. The output was two thousand barrels the first year. The next year the flow had increased to five hundred thousand barrels, and a year later to over two millions. Until 1869 oil wells were drilled in the States of Pennsylvania and New York only, and the product was five million two hundred thousand barrels a year. Since then, oil has been found in West Virginia, Ohio, Indiana, and California. The total petroleum output of the United States reaches every year the gigantic amount of thirty million barrels.

Meanwhile the oil under the name of its refined product, kerosene, has made its way into every European country, and by its superior illuminating power has driven off the field the more costly animal and vegetable oils which, outside large towns, were in general use. It has become a formidable rival to gas, which owes its survival mainly to the ready manner in which it can be supplied and lighted.

Russian petroleum wells are second in importance only to those of the United States. Long before the rich deposits of rock oil in Pennsylvania had been discovered, the petroleum springs of Baku, on the north shore of the Black Sea, had been known and utilized. The Venetian traveler, Marco Polo, who visited Armenia about the end of the thirteenth century, tells of a fountain "whence rises oil in suche abundance that an hundred shippes might at once bee loaded with it."

At first the Russian oil was put into goatskin bottles, and carried on the backs of camels to the villages in the interior of the country. At a later date barrels were used, and in them the oil was transported from Baku to ports on the Black Sea. The competition of the Pennsylvania oil had the effect of infusing some energy into the primitive working of the Russian wells. It was not till 1878, however, that vigorous measures were taken to utilize the enormous deposits known to exist in the Baku district. In 1882 the output was five million barrels. From that time progress has been great, and the production now nearly equals that of the United States.

Some of the wells have yielded supplies far in excess of the richest "gushers" ever drilled in this country. From one of the Russian springs the flow was fifty thousand barrels in twenty-four hours. But this enormous yield was not long maintained, and ultimately it ceased altogether.

From Baku to Batoum on the Black Sea a railroad has been built across the Caucasus — a distance of about six hundred miles — and by means of it the refined oil is conveyed for shipment to Europe. A pipe-line has recently been laid a portion of the way, and on its completion the cost of transit will be much reduced.

The greater part of the petroleum exported from America and Russia is carried in tank steamers. This mode of transportation was adopted a few years ago, and is found to be much easier and cheaper than the barrel system. The ocean steamers engaged exclusively in the trade number over seventy, and on the Caspian Sea one hundred and fifty smaller ones are employed. The larger vessels have a capacity of five thousand tons each. When a steamer arrives in port, the oil is pumped into tanks on shore. These tanks are usually underground, and, when properly constructed, they are not likely to get on fire.

Lesson XXXI.

Measuring Time.

In early Rome time was measured in households by water-clocks. These were peculiarly-shaped vessels, holding, each, a certain amount of water. This water issued through a hole in the vessel, and fell into a basin, in which floated a light body that rose as the basin filled. Lines running around the interior of the basin indicated the hours. Many improvements were made in the water-clock until a surprising degree of accuracy was attained.

A remarkable water-clock was sent by the renowned caliph Haroun-al-Raschid, as a present, to the most powerful European monarch of the Middle Ages, Charlemagne. It must have been a marvel of ingenuity; for in a good description of it, we read that it marked the end of each hour by the playing of cymbals and the appearance of knights in full armor, each of whom passed through a different window, fell into line with his fellows, forming a procession; they then all marched around a platform, and re-entered the clock through a window, which the last knight duly closed behind him.

It is not quite clear who invented the striking-clock. The first reference to its use in England appears to be made, in 1120, in the rules of a certain monastery, ordering that a monk shall read specified portions of the New Testament *till the clock striketh.* The watchmen, the night-police of the cities of medieval times, called out the hours as they were marked off by water-clocks or hour-glasses.

England's famous king, Alfred the Great, was very careful not to waste time, and he divided the twenty-four hours of each day into equal portions by means of time-tellers of his own invention. He had wax torches, or candles, made, each precisely of the same weight and size as every other one, and caused notches to be marked on every torch. Six of these torches, each one twelve inches long, were consumed in twenty-four hours, or fourteen hundred and forty minutes. As the notches were an inch apart, the burning of the wax to each notch indicated a lapse of twenty minutes.

But in the reign of King Alfred — he died over a thousand years ago — the art of housebuilding was in its infancy in England. The King soon discovered that the wind, rushing in through the chinks in the rude walls of the palace, made the wax burn irregularly. Seeking a remedy for this trouble, he found it in white horn, a material which can be scraped thin, and, in that condition, is almost transparent. With horn and wood he made a case for his candle, and thus kept it from flaring or uneven burning. How vast has been the advance in mechanic arts since the days when the monarch of England's clock was a candle shielded by a horn case!

The works of a modern clock are made of brass and steel, or, in clocks of the highest grade, nickel. This last-named metal is not so readily affected by changes in temperature — that is, by heat and cold — and hence clock-movements composed of it keep time more accurately than clock-works of brass. The cheaper kinds of clocks are made in factories, and come from Connecticut mostly. All the parts of ordinary clocks, even the cases, are cut out by machinery. When these different parts are properly fitted together, the time-pieces are ready for use; and, as a machine-made clock can be bought for one dollar, the poorest home in the United States can to-day have a measurer of the hours much more exact and convenient than any king in the world could procure five centuries ago.

An English traveler visiting, in the year 1500, Nuremburg, the industrial center of Germany then, wrote home: "Truly, these be marvellous times, and ingenious things are just now being invented; for Peter Hele, of this citie, as yet but a young man, hath made works which even the most learned mathematicians admire; for he fabricates small horologes [clocks] of iron, fitted with many wheels, and without weights, and, whithersoever way they be turned, they both show and strike forty hours, whether they be hung upon the wall or carried in the pocket."

These " small horologes " were the first watches, and were of almost every shape except round. Some were pocket almanacs, giving on their large metal dials the day of the month, the moon's changes, and other items of similar information. Most of these earlier watches were oval in form, and hence received the name of "Nuremberg eggs." Naturally they were regarded as prodigies of skill.

The most important difference between a watch and a clock is the watch's capability of running in any position, even upside-down; while a clock will not go unless held upright and steady. As pendulums and falling weights could not be used in watches, something had to be devised that would make the hands of a pocket-clock keep time.

If we look at the works of an ordinary American watch, we shall see a number of wheels and two short, thin, very narrow strips of steel, one called the *mainspring*, which is the source of motion in the watch, and another strip, much finer and narrower, known as the *hairspring*. So slight and delicate are hairsprings that three thousand of them weigh only an ounce. Instead of a pendulum to regulate the revolutions of the wheels, there is a heavy wheel, termed the *balance*, whose beats, or ticks, are controlled, to some extent, by the hairspring.

Most watches make sixteen thousand two hundred ticks an hour. So large a number of vibrations would soon wear the pivot holes too large, the pinions would work unsteadily, and the watch would become useless in a short time. To avoid this danger, the ends of the pivots are set in *jewels*, diamonds, rubies, or other hard stones.

The machines for drilling the pivot-holes in these jewels were invented in the United States not many years ago. Indeed, all the delicate and wonderful machinery used to make American watch-movements has been thought out by gifted men within the last forty years. Watches made in this country are the best in the world. Our great watch factories, employing thousands of skilled hands, have no equals in Europe. In fact, the unrivaled genius of American inventors has in no department of mechanical work been more brilliantly displayed than in the making of both clocks and watches.

LESSON XXXII.

Pottery.

To the ordinary potters are due the brown pans of the kitchen, our cheap tea and dinner sets, better sets of white and gold — often in several hundred pieces — and ornamental dishes of all shapes, designs, and prices. To the intelligence which directs their making must be added the genius of designers who decide the patterns, and of first-rate artists who paint the articles. So much valued is the very best ware, that royal porcelain factories were supported at Sèvres near Paris, and at Dresden in Germany, whose productions were fit presents for royalty.

Costly candelabra, flower-stands, enriched with colors and gold, burned in to last for ages, figures for ornament, reduced copies of sculpture and vases, in spotless Parian of every form of beauty, are found in rich homes of taste. The poorest, too, share in the benefits from the potter's art. It has long banished the old pewter platters and wooden trenchers of our forefathers, and given us instead an abundance of cheap, clean, bright and beautiful earthenware, which, if easily broken, is as easily replaced. Worcester is the seat of English trade in the finest china or porcelain, though a great part of the raw material is brought from afar. The great bulk of our earthenware is made in New Jersey.

Pottery Making.

An earthenware of fine grain and extra hardness, known as terra-cotta, that is, baked clay, has been of late in much demand, instead of stone work, for ornamenting the façades of buildings, and even for statuary. Terra-cotta is another instance of the part which intelligence takes in the work of production. The clay used to warp in the oven so much that figures got twisted out of shape before the firing was finished. After years of trial and failure, the potters have at last gained the skill in kneading the paste, molding the figures, and applying the heat, to allow exactly for this warping, and to bring out from the furnace the terra-cotta free from the least distortion, and just the size required.

China, a light semi-transparent ware, named from the country whence it was first brought, is the term given to the finest products of our potteries. The name porcelain is often applied to these same products from their resemblance to the inner surfaces of shells. Shells are smooth on the inside, and both they and the best china look as if they were coated with enamel-like matter. Porcelain was common in China for ages before the secret of its manufacture was known in Europe. The blue willow-pattern plate, with its curious figures, was at first the sole pattern made use of, and is still prevalent.

The Chinese seem to be a clever people, knowing, from time out of mind, the utility of many of of our modern discoveries, but never improving upon their own arts, as paper-making, printing, and gunpowder manufacture. The faculty of invention appears to have died out amongst them, from their belief that they had years ago reached perfection in everything, and that they could learn nothing from other races, whom they viewed as barbarians. But the powers of imitation of the Chinese are so strong that, as is related, when an order for some costly china was sent them with a flaw in the pattern, they copied the flaw as exactly as the design.

The potter's art is at least six thousand years old. Figures of laborers making earthenware at all stages of the process, from the kneading of the clay to the firing in the kiln, are found on the oldest Egyptian monuments. The Arabs, when they were dominant in Europe, became masters of the art, which in its modern perfection descends through them. They used lead and tin glazes, which so protected the designs and colors that they could not fade. The Romans had introduced the system of burning in the colors of tiles so as to make them more lasting. In many of the Roman villas unearthed in England the tiles are perfectly preserved, and have served as models for many of the tiles in our modern American buildings.

Recent progress in pottery consists, in a great measure, in copying or improving upon old examples. The potter's wheel is no longer turned by hand, but by treadle or steam power, and machines do the work of preparing the clay.

The art of the potter is rich in examples of genius struggling against poverty, of uphill work in face of failures, and of results beyond hope. Bernard Palissy, the Prince of Potters, who was born with the sixteenth century and lived to see it nearly out, was a French peasant boy, the poorest of the poor. He had no other books, he said, than heaven and earth, which are open to all. He

Potters and Pottery.

had no knowledge of clays, yet he sought to make enamels as a man gropes in the dark. He tells us that he wasted time, labor, and money. He still persevered. He taught himself to be as great a naturalist as nature can produce. In the end he succeeded.

Artistic Pottery.

He delighted to model the forms of fruits, flowers, shells, fishes, and reptiles. His graceful groups of figures, his vases, and the other remaining productions of his beautiful art, are now regarded as priceless treasures in the French national museum, the Louvre.

What is the lesson to be learned from the lives of eminent men? We call them men of genius, and say that their success is owing to their genius. Intelligent scholars will see that genius means the power of patient and continuous application. The greatest genius is the hardest worker. Real love for art shows itself by steady daily work towards excellence. No artist can paint a perfect picture, or model a perfect group, without practice. Men of talent, without application, remain untaught and obscure. No doubt, naturally clever persons can attain success more easily than ordinary people; but unless the most gifted minds work they will be beaten. There is no chance in genius. Men of genius make their own chances. A steady, industrious boy, inspired by longings after excellence, has genius of high order, the genius of diligent work.

LESSON XXXIII.

In Toyland.

Is toymaking an every-day occupation of much money importance? Indeed it is. Hundreds of thousands of people depend for a livelihood on the trade in playthings. One small city in Germany, Sonneberg, situated among the mountains of northern Bavaria, sent in 1890 over two million dollars' worth of toys to American children. Several large villages in the Austrian Tyrol and a dozen or more in Switzerland have been built up by the manufacture of toys and nothing but toys. These little joy-makers for young people represent many millions of dollars.

To see some of the oldest citizens of Toyland, let us step into that noble institution in London, the British Museum. Here we find various playthings that made young folks on the banks of the Nile, or perhaps in Central China, happy, ages on ages ago. These companions of children of forgotten tribes are well cared for, we notice; and their attendant assures us that they are treated with great respect by all their visitors. Even the most shabbily dressed doll here awakens more interest than any modern member of her family, however gorgeously appareled in silk and lace.

Do you see that rudely modeled small statuette in the glass case? Strings of tiny black beads dangle from its ball-like head. Those were meant for hair. That doll must enjoy a green old age we feel sure when we learn that she was found in the mummy case of a little Egyptian princess who died two thousand years before the Christian era.

On the shelves we perceive numbers of playthings belonging once to youngsters who lived, possibly, in the aristocratic quarter of Babylon, or, it may be, in narrow Damascus courts, or in some long-vanished, walled city of Chaldea. There are painted balls, whistles of ivory, bronze birds with nodding heads, open-mouthed clay crocodiles, ludicrous little animals on wheels, toy-drums, bronze cymbals, small but musically toned, and dozens of other different kinds of fine toys.

What modern toy-shop can show a prettier plaything for a little girl than this small bronze cooking-stove, with its array of tiny metal pans, kettles, and basins to match? We find ourselves fancying the young "Atai"—to whom it belonged—busily preparing by its aid a feast for her playmates, in the cool courtyard of some magnificent house in Memphis, an ancient Egyptian city, amid whose enormous ruins it was found.

Judging from the large collection of their specimen toys here, the youthful Greeks did not lack the means of amusing themselves out of school. Amusement *in* school was likely to be followed by severe flogging in ancient Greece; hence if these toys were ever inside a schoolhouse there, it is probable that they remained in their owners' pockets.

Children's tastes seem to have been much the same in all ages. These time-worn Grecian playthings are like American ones of to-day — hoops, dolls, houses, birds, and boats. Here is a terra-cotta dancing-doll which was dug up a few miles from the famous battle-field of Marathon. Holding to her beating heart this clay toy, its little owner may have gazed, awe-stricken, at the Greek soldiers marching past her father's house on their way to win that glorious victory over Asia's hordes, twenty-four centuries ago.

Those extraordinary red, black, and blue jointed playthings yonder are from Java. Poonah calico toys are these on this shelf — neat, mimic animals made of cotton cloth, and stuffed with combed jute. They are very life-like and come from the central part of Hindustan. Elephants, camels, ferocious little tigers, tiny monkeys biting cotton oranges, and many other imitations of members of the animal kingdom, all astonishingly accurate, are made in Poonah. Numbers of terra-cotta playthings are fashioned also in the same district.

Japanese Toydom is a wonderful realm. Among its citizens are paper dragons with wings that carry them up into the clouds ; arrows to be thrown with the hand ; wooden turtles that can walk and wag head and tail ; peg-tops that, while spinning, open and throw out other tops, also spinning ; paper butterflies that actually fly ; nests of eggs, each egg having a dozen eggs within it — and there are hundreds of other toys just as odd and interesting. The ingenuity exhibited by the Japanese well entitles them to be called the Yankees of Asia.

The excellence of the toys in Japan may be due somewhat to the fact that they are used more by the old men there than by the boys. In that strange land the fathers fly kites, each man excitedly striving to coax his kite to the greatest height possible, while their little sons stand by gravely watching the contest. How ridiculous such a scene would appear in the United States ! Yet we must remember that custom makes many queer amusements seem reasonable. The Japanese are brave, polite, intelligent, hospitable people, and are so kind-hearted that cruelty to animals is utterly unknown in their country. Perhaps if a school-boy in Japan were told that in America full-grown men, many of them middle-aged, hire out to chase a little ball about a big field, he would get a wrong impression of the character of American men.

During the Middle Ages the quaint old city of Nuremberg, in Germany, was the headquarters of toy-making. Hand-work was then the rule. Artists carved out dolls, no two of them having faces alike. Indeed, the manufacture of dolls after one model was not known till trades, by dividing into branches, called for less variety in each artisan's work. When wealth, learning, and taste began to manifest their combined powers in the French capital, Paris, the aristocratic doll, the waxen beauty with glass eyes and blonde tresses, emigrated to that city. There she became, in a singular way, the forerunner of fashion.

Rapid, accurate, and cheap illustration of newspapers and magazines was then entirely a thing of the future. The secrets of lithography and of electrotyping — arts by which plates of dress styles can now be produced at low cost — were secrets waiting to be discovered. "How can we send to distant cities good, cheap patterns of new styles?" queried the puzzled Paris dressmakers and clothiers. The doll and her big brother stepped forward in answer to the question. Attired in the height of Paris fashion, doll models were despatched far and wide to arouse admiration in the hearts of all beholders. Dolly and her brother — a little Paris dude — thus became the first "drummers" of modern trade.

Sonneberg, Germany, is the center of European doll manufacture. About how many dolls, should you guess, are annually exported from that one small city? Probably you would not hit on the nearest round number — thirty millions. And dolls are made by millions also in other cities of Germany! This quiet Bavarian town produces tons of other toys — a specialty being soft, furry, little animals of all kinds. Some of these toys are very ingeniously made. Cows moo, monkeys play on fiddles, rabbits clash cymbals and beat tambourines, roosters crow, and cats eat, lap, and caterwaul! We receive a hint as to some of the means employed to produce these amusing results, when we learn that every year over forty million feet of wire are used in making these animal toys. Large quantities of thin brass ribbon and of india-rubber in sheets are also consumed.

In the simple but highly artistic industry of wood-carving the Tyrolese and the Swiss excel. Brienz, a lovely village in the central portion of Switzerland, has long been noted for its superior work in this primitive fine art. The village consists mainly of one long, straggling street, lined with quaint brown houses on either side. The only large building is the School of Design. This was erected by the government for the benefit of the people generally. Here, those who have taught themselves how to carve the soft mountain pine may come to have their faults corrected, and beginners may get thorough training in drawing, modeling, and the handling of wood-cutting tools.

Many of the productions of these mountain sculptors in wood are marvels of taste. Standing before some fancifully carved piece of furniture, a cabinet, a writing-desk, perhaps a cuckoo-clock, or an arm-chair, the visitor from the United States is amazed to learn that such beautiful work was done with a few simple tools. It should be remembered, however, that the carver put his soul into his work. What his hands found to do he did with all his might.

The quaint busy little town of St. Ulrich, in the southern Tyrol, is celebrated for the manufacture of jointed dolls. Numerous warehouses are filled with these favorites of all little maids the world over. The sizes vary from inch-long mites to giants, each three feet tall. Every store has a room for every size of doll, and all the rooms are filled. One of the great merchants of St. Ulrich sells on the average forty thousand two-inch dolls every week in the year!

Specimens of almost all the wooden playthings we are familiar with are to be seen everywhere in this village. Noah's arks, armies of wooden soldiers, millions of domestic beasts, sets of tableware, horses, carts, wheelbarrows, farm tools — in short, toys, toys are on all sides.

It is a long flight from St. Ulrich to a tropical forest of Buadi, in northwestern Brazil; but as we have wings of the imagination we can make the journey in an instant. Here we are in the middle of a dark, silent swamp, ready to observe the collecting and preparing of that material of which so many toys are made nowadays — rubber. It is early morning. All around us are rotting logs and pools of muddy water, covered with thick green slime. Long festoons of moss hang from the branches overhead; dark mold covers every tree-trunk; malaria is in the atmosphere — an atmosphere never purified by a ray of sunlight; the oppressive silence is unbroken by bird or beast; we are alone with decay and death.

The sound of splashing water falls on our ears. Wading across yonder oozy, sluggish stream, come dark-complexioned Indians bearing baskets, filled with large clay cups. These Indians are Guaranis, and are as silent as mutes. They gash the rubber-trees with hatchets, brought slung around their necks by green vines. Where the milk-like fluid drips from each gash, a cup is fastened with clay.

If the tree is a large one, five or six cuts are made in a circle around the trunk. To-morrow another row of cuts will be made below those, and so on until the rows reach the ground.

By eleven o'clock the flow of milk has ceased, and the contents of the cups are poured into jugs. Two gills is the utmost yield from a tree, and one gatherer can attend to a hundred trees. If the milk be left in the earthen vessels, it will, after a time, coagulate, and form inferior, whitish gum. To make the black rubber of commerce, the liquid must be put through a peculiar process of evaporation. Over a smoldering fire the Indian rubber-maker places a kind of clay chimney. It resembles a wide-mouthed, bottomless jug. Through it volumes of thick smoke pour steadily. Now the Indian dips in the milk a short, round-bladed paddle, and holds it over the smoke till the liquid coagulates. Another coat is added, the milk drying faster now, because the paddle is hot.

It may take the gatherings of two or three days to cover the paddle thickly enough. The rubber is still dull white, but in a short time it will brown, and finally will become almost black. Then it will be ready for market. Most of the Brazilian rubber, however, is made by evaporating the milk in heated clay pans. The Indians of the Buadi swamps are the only gatherers employing the paddle-drying method above described. The milk obtained from the cow-tree is coagulated with alum and water, and is then allowed to dry. This kind of rubber is not used for toys, it being too hard.

Now let us take a glimpse at the manufacture of rubber toys. Rubber, torn into bits, is mixed with white lead. The mixture is slowly melted into a pasty mass. This is then rolled out into sheets of the required thickness. These sheets are not elastic; they seem more like layers of dark putty than of rubber. With this unpromising material a workman fills an iron mold, which opens in halves, hinged together at the back. When the mold is closed, we see that it is the figure of a doll. Hundreds of other molds of various shapes are lying on a table, all ready to be vulcanized.

Vulcanizing is done by putting the molds in an immense iron box containing a certain amount of sulphur. They are left for some time in this box, which is kept hot by steam. When the hardening process is complete, the molds are taken out, the halves thrown apart, and toys warranted to outlast any others are before us. The seams formed by the mold-joinings are trimmed down, and the toys are all ready for the retail dealer. Hereafter, when you look at playthings, cheap or dear, you will remember that the making of them has employed many hands, will you not?

Lesson XXXIV.

Where Sand is Melted.

During the Middle Ages glass-blowers were regarded, by simple-minded persons, as uncanny beings, and were avoided as much as possible. "Unless a man had dealings with the Evil One," said the superstitious, "how could he, by blowing with his breath, change dark flint-stone into a transparent thing?" Perhaps even in these enlightened times a good many persons could be found who would be unable to give a satisfactory answer to this absurd question. We have already read in Lesson XXV., a little about the history of glass-making. Let us now visit a glass-works, and see for ourselves how sand and flint are turned into that beautiful substance which poetical Venetian merchants long ago described as "solid water."

We observe that the glass factory is an odd-shaped building, having chimneys of great height. The guide assigned to us by the superintendent remarks that it would be best to go first into the "cave" in order to look at the "eye." Such an invitation would arouse any one's curiosity, and we follow him down into a cellar and then along an unlighted, wet, wind-swept passageway. We hear no sound except the steady drip-drip of water falling on both sides. All at once we find ourselves in an immense vault, pitch-dark in all parts, except in the center, where there glows a square of red light on the floor. This red square is the "eye." Overhead glares the furnace fire that turns sand into glass. The cave provides, by means of the passage, a steady draft to keep this fire burning constantly.

A figure darts out of some dark niche above us, crossing from the cave's side on a plank to the furnace, and plunges a long poker into the depths of glowing coal. A burst of flame and a shower of embers are the results. Unwearying care is taken of the furnace fire. Only once in three years is it allowed to go out. The grate would be burned through were it not for the strong draft of air continuously passing up between the bars.

Following our conductor, we grope our way up a gloomy staircase, and emerge in the "grinding-room." The workmen are covered all over with white dust. Flour? No; it is a peculiar kind of slaty earth, ground as fine as meal. Containing but little lime or iron, it is the only clay that can be relied on to resist intense heat. Having been powdered, it is shaken through fine sieves, and is then mixed with one-fourth of its weight of ground-up earthen vessels, which have been burned in the furnace.

The clay meal is now wet with water, and is kneaded into large slabs, which go to the pot-makers. One of these workmen cuts off thick slices with a stout wire tool, having a handle at each end. Each slice is rolled, to exclude air-bubbles, and is passed on to another worker, who builds up a huge, round vessel by carefully adding slice to slice. He smooths each strip of clay, in one direction, to guard against the entrance of any air during this slow process of pot-making. Bit by bit, the gigantic flower-pot is made. It reminds us of the building of a swallow's nest — a bird home which is put together, as we all have noticed, in much the same painstaking way.

Yet though the pot-maker's work is slow, it is not always sure; for, as the workman himself tells us, vessels made out of the same clay slab, and by the same hand, will, in the most unexplainable manner, vary in their powers of resisting heat. As these enormous pots hold the materials to be transformed into glass, the breaking of one of them in the furnace is a serious loss. Some pots will last for months, others will fall to pieces in a few days.

Before being used as kettles in which glass-making substances are boiled, these vessels are gradually dried in heated rooms, where they remain seasoning for weeks. When they are wanted for firing purposes, they are placed in a firebrick kiln. Here they are brought to a red heat, removed, rapidly filled with the materials required to make glass, and run, still hot, into the furnace.

What is the principal substance employed in glass-making? Silica; and silica is found in flint, sand, rock-crystal, and quartz. Nearly all glass-factories are located in districts in which suitable sand can be obtained easily. Our guide takes us out again into the yard, and shows us sheds filled with dry, glittering, whitish sand.

These half-barrels in this little iron-sheathed building are filled with a soft, heavy, reddish material. "What is it?"—"Red-lead, or minium," replies our chaperon; "it is used in the production of flint-glass. No, it has no relation whatever with the so-called black-lead, which is really iron combined with carbon. This red-lead is the oxide of ordinary lead—the kind of which bullets are made." He further explains that when lead is melted, a scum soon forms upon its surface. This scum is made by the action of the oxygen in the air on the molten lead. Red-lead is produced by melting common lead in iron ovens, and stirring it constantly, till it is all oxidized.

Other materials are also required for glass-making. There must be an alkali, such as soda (natron), potash, or lime. Sometimes a little pulverized coal is used with the object — astounding as it may seem — of rendering the glass colorless! These substances, mingled with sand, are first to be baked into "frit" — that is, they must be put into an oven, and be heated till they are thoroughly dry, and the sulphur in the minerals is driven out. If it were allowed to remain in the frit, the glass would not be clear. After being heated for some time, the frit becomes pasty. It is then raked out, divided into blocks, and permitted to cool. When it is quite cold, the big round vessels may be charged.

A pot is filled one-quarter full of crushed frit, and is placed in the furnace. When that quantity of frit boils, more is added. The filling and the melting are repeated till the vessel contains the requisite amount of boiling liquid. On the top floats a thick scum. This is removed by monster iron skimmers.

A few pieces of broken glass are now thrown into the pot, in order to purify the material by causing any excess of soda to rise to the surface. Skimming is once more resorted to, and the thick fluid is heated again — this time to a higher degree — in order to expel its gases. At last it becomes quite clear, and is then ready for the glass-workers.

Our guide having finished his explanation of the boiling of glass, leads us into a big circular building. What a change from the quietness of the yard! Hundreds of men and boys busily at work, short, sharp reports, like the explosions of fire-crackers, glaring furnaces on every hand, weird shadows that come and go in an instant — such are some of the features of as strange a scene as can be witnessed in the wonderful land of Labor.

We are now above the cave, and the fire we saw below is boiling scores of pots of glass in this large brick tower with its half a dozen port-holes all aglow. We try to look into one, and are blinded for a moment by the intense light of the seething fire within. Yet the frit remains ten hours in such a fire before it boils!

Yonder is a man wielding an unusually long poker. Our conductor corrects us. It is no poker, but an iron tube with a mouth-piece; it is a *ponty*, the glassblower's chief tool. The workman, dipping the ponty's end into a potful of frit, twirls the tool round and round till he has gathered a small quantity of molten glass. Flying with the ponty to a sloping iron table, he rolls the glowing glass thereon for a few seconds, causing it to assume a pear-like shape. Next, he holds the tube out, and blows steadily through the mouth-piece. To our amazement the little lump of pasty glass quickly swells to the size of a football! The blower turns the ponty down, and, still blowing, swings it gently to and fro. He touches the glass to the ground — and the football stops growing!

Raising the iron pipe, he blows again through it, and again the ball of glass expands; but this time only the thick soft sides widen out. Now he pinches a small knob, about the size of a vest button, on that part of the glass globe opposite the ponty's end, and hands tube and glass to a boy running by him. Without waiting for our guide, who follows us, we hurry after the boy. There he is! What is that clumsy-looking wooden apparatus near which he is standing? The man in charge of it tells us that the machine is a lathe by means of which glass is turned to any desired shape. He adjusts the blow-pipe, rotates it in the lathe, and with a singular pair of nippers twists off the little knob in the center of the glass bulb, leaving a small round opening.

The boy now seizes the ponty, and running with it to a furnace, thrusts the glass into the fierce flame, waits a moment, and then hurries back to the lathe with his charge. Again the turner sets the tube in the wooden arms, starts up the machine, and, while the red-hot glass is revolving rapidly, he pushes an iron blade into the opening made by the removal of the little knob. This opening enlarges very fast. A moment ago a cent could not have been passed through it; now, it will admit a saucer. A slight downward pressure of the blade gives the aperture a graceful outward-curving rim, and the lump of paste-like frit has become a lamp-shade!

Of course it must pass through other workmen's hands before it will be fit for sale, but they will not change its form much. The shade is now in the rough, indeed, but is nevertheless all ready for use, so far as its merely useful qualities are concerned, except that it requires annealing.

"What is annealing? how is it done?" we ask our guide. For answer he conducts us to a long, narrow, brick gallery. Boys are placing in it iron pans covered with newly-blown glass vessels. At this end there is a coal fire, sunk below the level of the floor. The pans of hot glass articles are drawn very slowly through the gallery, the heat gradually lessening, until, in twenty-four hours, they come out, at the other end, nearly cold. After being annealed, glass vessels lose part of their brittleness, and are not easily affected by sudden changes from heat to cold or the reverse.

Of late years, toughened glass, so-called, has been made in large quantities in Paris. A tumbler fashioned from it can be thrown down-stairs, or be used as a plaything, without suffering any damage thereby. To make this glass, the blower stands by the side of a large iron vat filled with oil. In the vat is a wire cage, or basket. The glass-blower, having shaped his tumbler, or other article of table-ware, removes it, with two or three taps of cold iron, from the ponty; and, while the glass vessel is still extremely hot, he lets it drop into the cage. It sinks down gurgling into the depths of boiling oil, in which it is allowed to cool gradually, and out of which it comes an article of glass not readily broken.

To explain the nature of this kind of glass, an interesting experiment is performed for our benefit. One of the workmen lets some drops of molten frit fall into cold water. They instantly harden into cone-like forms. One of these is handed to each of us with the direction, "You must break off the point." We do as directed, and the little crystal cones fly into a thousand pieces — vanish out of our hands!

These small glass drops are made by the million for the toy stores, and are called Prince Rupert tears. The interior of each of them is composed of particles of frit, which were suddenly com-pressed by the cold water, and which are held together in a state of intense strain. When their compresser, the glass covering, is broken through, the particles, relieved of the pressure, fly in all directions. The glass was not annealed. If the surface of a toughened glass article be broken, the article will, like a Prince Rupert tear, burst into minute fragments.

"Would you like to see the operations of glass cutting and grinding?" We answer "Yes," to our conductor's question, and stepping with him into an elevator, we are carried to the top story of. the works. The room which we enter has windows in the roof and sides. We see along the walls wheels, pulleys, belts, lathes; overhead are shafts that supply the motive power here; scattered on the floor are boxes of various glass articles, and small tables are ranged in rows in the center.

At a wheel near us stands a white-aproned man, grinding some glass object. Apparently he holds it as firmly against the iron rim of his wheel as if he were ignorant of the fragile nature of the vessel in his hands. We examine the grinding apparatus, and then question our guide. No, he informs us; diamond dust is not employed to do such cutting as is done here. Wheels faced with iron, stone, wood, cork, and bristles are used. No help from the diamond is needed.

Let us watch this workman make a cut-glass tumbler out of that rough one he has just picked up. He presses it first against an iron wheel, on which water, thick with fine sand, drips steadily from a tin vessel above. When he has roughly cut the required facets on the tumbler, he takes it to a grindstone, which smooths the flat portions. Scratches are, however, still visible on the facets.

The next wheel to which he goes with the tumbler is a wooden one, but that whitish compound on the rim is, our guide tells us, a paste of ground pumice-stone and putty, wet with water. Sometimes a mixture of lead and tin is substituted. After using this wheel, the cutter scrutinizes the tumbler closely. Seemingly, he is satisfied; for, stepping to a small wheel edged with thick, short bristles, he completes his work in a few minutes. In the sunlight the tumbler is now seen to have that brilliance peculiar to diamonds and cut-glass ware.

Our intelligent and courteous guide tells us that in cutting and in grinding glass the moderns far excel the ancients. No American has, it is true, he says, produced a work of art in glass equal to that Roman masterpiece, the Portland Vase. But in the United States are made telescope lenses so powerful that they reveal to us suns so distant that a ray of light from any of them, though it travels eleven million miles a minute, requires a thousand years to reach our earth. Again, we can make microscope lenses so high-powered as to enable us to prove that a drop of the clearest water swarms with lower orders of animal life. Compared with these achievements of to-day's glasswork, Egyptian, Greek, and Roman triumphs in the glass industry are beneath contempt.

Surpassingly beautiful glass imitations of flowers and certain small marine animals are produced by artists of our own times. Visitors to our large museums of natural history note with admiration the fidelity to nature of many of their glass models. Sea-anemones and jelly fishes are so faithfully copied that ordinary observers believe them to be alive. Equally fine flower models are produced. Plants in bud and in bloom are made so natural in appearance that the spectator is startled to discover that they are imitations. There is not the least hint of glass about them. The ancient world has left us no similar art-work of such extraordinary merit.

LESSON XXXV.

Made from Wood.

IT is difficult to realize that three thousand years before our continent was discovered, Egyptian, Assyrian, and Phœnician carpenters and cabinet-makers produced very elegant articles of furniture, and had already devised almost all the different implements used in working wood by hand. Those skillful men of old had varied collections of saws, chisels, drills, planes, mallets, and all the other tools that you would be likely to find in a carpenter's shop to-day.

Cut on ancient Egyptian monuments are pictures of wood-working shops equipped with rollers, wheels, belts, pulleys, hoists, and other machine-tackle common in all modern furniture-factories. Workmen are seen fashioning sofas, flower-stands, inlaid tables, buhl cabinets — articles of luxury which convey pleasant ideas of the comfort enjoyed in homes by the sacred Nile many centuries ago.

We are apt to regard bygone ages as barbarous; but the ingenuity and the taste shown by the wood-workers of ancient Egypt, of Persia, of India

—in short, of all the empires that rose and fell prior to the Christian era, might well make us change our opinion.

One of the oldest public buildings in London is the hall of the joiners and ceilers. Those artificers were formed into a guild, or company, in the reign of Queen Elizabeth. The building has some curious Biblical frescos representing the first craftsmen in wood: Noah is humbly listening to the Lord's commands concerning the construction of the Ark, and, in another part of the same painting, are shown the patriarch's three sons engaged at the task; King Josiah is portrayed directing the repairs of the Temple; Joseph is seen busy in his shop, and some jeering Nazarenes are saying (we are told by a black-letter inscription), as they point at the new teacher, "Is not this the carpenter's son?"

Wood-working has to-day, like many another industry, passed from hands to machines. Lathes, operated by steam, fashion the various parts of different articles of furniture; moldings, panelings, cornices, doors, and other portions, once prepared by hand, are now cut by revolving chisels, and planed, and even sand-papered by machinery.

The lumber-sheds of a large furniture-factory contain several kinds of home and foreign woods. Elm, walnut, whitewood, maple, birch, ash, pine, cherry, and oak are the most common furniture woods found growing in the United States. Satinwood, mahogany, and rosewood, three varieties much used in pianos and other costly household articles, come to us mainly from Central America.

Within the factory buildings the *whirr-r-r* of machinery almost deafens the visitor. Most noticeable is the perfection of the machines. The employés seem merely their servants—hired to attend to their wants. By the time we have noted half the wonders done by these complicated iron artificers, we shall not feel very much astonished, if we are told that some machine here can transform a few boards into a bureau, or a bookcase, in a minute or two.

Logs of ordinary wood are cut into planks by gang-saws. Each of these saws can divide a log into twelve boards at one operation. Circular and band saws also form part of the factory's equipment. The more expensive logs are cut by a horizontal saw, which can take off only one plank at a time. At each cutting the log has to be lifted and wedged. There is, however, much less waste of timber than would result from the use of a gang-saw.

Let us walk through the different shops. The first room we enter is the fitting-room. Here the separate pieces of an article, a chair for instance, are put together. Glue-pots and mallets are visible on every bench. The fitters are paid by the piece in this factory, and they do not waste time, therefore, in staring at us. As we watch them, we observe that their occupation calls for a great deal of energy, indeed; but a high grade of skill does not seem essential.

The upholstering-room is large, quiet, and well lighted. Numerous shelves are laden with textiles of various kinds and qualities, — velvets, carpetings, damasks, plushes, and other fabrics. Here we see shining horse-hair, crimped and curled that it may not wear through its future coverings; bales of wool are piled in yonder corner ; cotton-batting and "excelsior" (wood-shavings), are also here in large quantities. We note the wonderful difference between the skeleton sofas just being lifted off the elevator, and the finished couches, upholstered in silk plush, all ready, over there, for the salesrooms.

Polishing is done in another room. Men are at work bringing out the grain of valuable woods. The surfaces, planed and sand-papered, require a good deal of rubbing with shellac and oil. This operation not only renders the wood more attractive, but also preserves it from splitting and discoloration. Furniture of the cheaper kind is merely varnished and painted. Sometimes, however, the wood of which it is made is grained, to imitate a higher-priced kind. Graining is done by putting on coats of white and yellow paint, and, when these are quite dry, brushing thin transparent "glaze" on the surface, and then combing the moist glaze with a broad, flat, elastic comb. This streaks and grains the portions over which it is drawn. A bone-tool, like a paper-knife, a bit of rag, and occasionally the worker's nail even, are used to aid in producing good effects. When the graining is completed, the surface must be allowed to dry thoroughly before it is varnished.

The hardest, heaviest, and most expensive of all woods is ebony. At certain seasons of the year numbers of dark-hued native laborers, employed by a white agent, visit the dense forests of Ceylon or of Madagascar, where abound the precious ebony trees. The men do not go very heavily equipped. They take with them, in a few oxen-drawn carts, some crockery cooking-vessels, a plentiful supply of provisions, mostly rice, and their axes. Like our own lumbermen, they often have to cut their way through tangled thickets.

Penetrating slowly through dense masses of tropical vegetation, they pass by, with scrutinizing looks, many valuable trees. On and on they go, until at last they meet with a cluster of ebons, stretching widely, far above the heads of their human foes, long branches laden with sour, unwholesome fruit. Without pausing to rejoice, the dark woodcutters begin to hack at the hard, gray trunks. Steadily the chopping is kept up, till tree after tree has been felled. The trunks are then hewed into four or five lengths each. These have to be peeled deep; for the "black of black ebony" is only the very heart-wood of the tree, a kind of inner trunk, which has to be cut out of its sheathing. Placed on the ox-carts, the wood is carried to the nearest stream, and left to soak therein for some days.

Ebony formerly fetched a very high price, — a higher one than it has commanded since it has been so well imitated by dyeing several other hard woods. Nowadays it is used not so much for furniture as for various small articles, such as rulers, chess-men, mouth-pieces for clarionets, stands, and violin bridges. In all the countries of south-eastern Asia it is the material from which are carved figures of various gods. It is also much employed, with sandal and other sweet-scented kinds of wood, to make beautiful inlays.

Most of the valuable logs which we see here will be sliced into veneers, after having been sawed into planks. What is veneering? It is the attaching of a thin sheet or strip of costly wood to a body of more common wood. Both kinds of wood must of course be thoroughly seasoned before the veneering is attempted. Most of the rare woods can be obtained in small logs only. Twisted roots, and huge, gnarled, forest-tree wens are also much prized for veneer-work. Their graining is odd and unusual, and, owing to their mode of growth, they are much more close-fibered than the trunk wood of the trees from which they were procured. The veneer-cutting machine can divide an inch-thick board into twenty perfectly even sheets of wood.

The surface of the wood to be veneered is first roughened in order that glue may take a firmer hold of it; the veneer is also prepared with a rough side, the smooth side having paper pasted on it; then the wood is placed on an iron table, and is quickly brushed all over with a peculiar sort of hot liquid glue. The veneer, laid on the wood, is firmly pressed down by workmen, who hammer evenly over the whole surface, carefully driving out all the air-bubbles. If these were left in the glue, they would prevent the complete adhesion of the two woods. Veneer and base are next put in a heavy press, and are squeezed tightly together. A great deal of the glue is forced out between the edges. The woods, left thus under pressure for about thirty hours, form a very strong board.

Then the press is unscrewed, the veneer's paper-protector is washed off with hot water, and the polisher takes the article in hand to beautify and to strengthen it by rubbing it with shellac and linseed oil.

When veneering is to be applied to carved surfaces, thin pieces of wood, having been cut to fit the curves, are heated, covered with glue on their rough sides, and kept on the wood by clamps till the drying operation is completed.

Marquetry is a kind of veneering seen on high-priced pianos, ornamental tables, and other fancy articles of furniture. A workman explains the process to us, as he embellishes a lady's writing-table with tulip-tree wood and fine ebony. We note that he glues together four sheets of these woods, wipes off the glue that exudes at the edges, and dries the bundle. On this he then pastes a paper pattern. Now fastening the bundle in a vise, he proceeds to bore a small aperture through some portion of the design that is to be cut away. Through the hole he passes a thin watch-spring saw, and sets it in its light but strong frame. Following out the pattern's lines with this saw, which, we perceive, runs in his hands smoothly and swiftly, he soon has the square slices of wood transformed into things of beauty. Then he separates the several layers of wood with a knife, and shows us how exactly and neatly the sawed woods match, and form one surface. He joins them with glue, mounts the pattern on stiff paper, cuts with a graving tool a curve here and there, burns the other lines into the wood, and deepens the tint with hot sand. The result is a work of artistic appearance.

Sheets of ordinary woods are cut as thin as veneers, to make the back and the front of that valuable instrument, the violin. In the most music-loving of modern countries, Germany, there is a town called Mittenwald (a word meaning "in the middle of the forest"), situated in southern Bavaria, and noted for the enormous number of violins manufactured there annually. The lofty Bavarian Alps rise near this busy community of several thousand souls, forests close around them, and they seem to be hidden away from the rest of the working world.

All observant sight-seers that, during the past decade, have visited this peaceful village, tell us that the quaint old place presents an exceedingly odd sight. One might easily believe that all the fiddles in the world were made there. Musical instruments are to be seen in every direction, and in every stage of construction. On window-sills, doorways, from projecting rustic roofs, from limbs of trees, and on fence palings are hung portions of violins, violoncellos, violas, lutes, zithers, and guitars. Violin timber has to be selected with great care, and must be well seasoned before being used. It will surprise you to learn that there are over fifty different pieces of wood in a properly made violin. Some of the parts are sold by dealers to the Mittenwald artificers, and these dealers also buy the completed instruments; therefore, when the violins are sold again to shopkeepers, the dealers have made two profits off the same pieces of wood.

The genuine violin, which first appeared about the end of the sixteenth century, soon eclipsed all other stringed instruments. The most famous makers lived in Cremona, Italy, — Straduarius, Guarnerius, and the Amatis. Many of their instruments have sold for thousands of dollars apiece. Jacob Steiner was the most celebrated of the early violin-makers of Germany. He was an inhabitant of Mittenwald, but he learned his art in Cremona. When he returned to his home, he began to produce instruments rivaling Italy's best; and he soon made his name and town known throughout the musical world. A favorite Latin motto on the better grade of violins, the letters being inlaid in the wood, may be translated thus: —

> "Speechless, alive, I heard the feathered throng;
> Now, being dead, I emulate their song."

"Cane plantations" is a phrase which will suggest sugar to the young folks who have read "Information Reader, No. 1;" but it may interest all to be told that in various European countries there are acres and acres of forest, carefully tended, which are drawn upon for material to make walking-canes. Beech is the favorite timber, being light and pliant.

If straight, smooth canes are desired, the wood is sawed into strips, each about three feet long and three inches wide. These are cut into the required shape, planed and polished. Should "natural wood" sticks be wanted, —and these are nowadays much in demand, — the tree-branches, after seasoning, are cut the proper lengths, and placed in wet sand. Therein they become pliable, — ready to be straightened, and to have the larger ends bent into crooks or curves. To form an angle or hook, the softened wood is put into an iron frame adjusted to the desired bend, and is allowed to remain thus warped for some time. Then the handle is heated, — an operation that fixes the wood fibers in their bent position.

While mentioning the various kinds of canes, we must not forget the light, cheap, and strong rattan ones. These are young shoots of palm-trees, and are brought in large numbers from

China, India, and Japan. Rattans are much used in the framework of cane chairs, settees, work-baskets, children's carriages, and fancy stands. In the depths of Hindustan forests, where these hollow canes are found, natives of the country use a long, creeping cane, a vine, as a lasso for capturing the strongest of all beasts, the wild elephant. Other cane creepers are plaited into mats, baskets, ropes, and hammocks.

Walking-sticks made of cabbage-stalks might well be deemed curiosities, but they are common enough in Great Britain. They come from the Channel Islands, which, you can see by your geography lie south of England and near the French coast. These cabbage-stalks are stripped of each leaf as fast as each one appears, the stems being allowed to grow as high as they will. They are cut down, dried, hardened, and then prepared like ordinary sticks.

Umbrella handles are, we know, to be had in "natural wood" styles, or made of smoothed tree-branches, perhaps carved, or otherwise beautified. In the United States umbrellas are so common that we are puzzled to understand why they should be emblems of royal power in Eastern lands. One of the rulers of Farther India signs himself as "Lord of the twenty-four umbrellas." Here is the first paragraph of a letter written not long since by the Emperor of China to the King of Burma:—

> "The Royal Elder Brother, Tan Kwang, Sovereign of China, who, assisted by the Ruler of Heaven, exercises authority over a multitude of umbrella-bearing chiefs in the great Eastern Empire, affectionately addresses his Royal Younger Brother, the Sun-descended King, the Lord of the Golden Palace, who governs a multitude of umbrella-bearing chiefs in the great Western Empire."

The umbrellas of the East are, in reality, sunshades. The first one was probably a dried palm-leaf, this leaf having ribs and a handle attached to it by nature. The Ainos of Japan make, even to-day, sun-protectors of the leaves of a gigantic dock-weed, growing in Japanese marshes.

A Korean gentleman, caught in a rain-storm, pulls out of his flowing sleeve a folded, oiled-paper article, resembling a fan with two handles. This fan is opened, set over the hat, and kept in place by strings tying under the chin. Siam's emperor has slaves hold over his head, whenever he leaves his palace, an umbrella, or parasol, that looks like six tambourines of graded sizes, the smallest tambourine being at the top. Any Siamese reckless enough to be seen carrying a duplicate of the imperial umbrella would lose his head in short order.

Italy was the first of the European countries to adopt the Egyptian canopy as a sun-protector.

"Ombrella" is an Italian word, signifying a thing that makes a shade. About the middle of the last century General Wolfe, who captured Quebec in the French and Indian War, writing from Paris to a friend in London, says that French people use umbrellas to protect themselves from sun and rain; and he adds, sensibly enough, that it is strange to find so rational a fashion unknown in England.

Tradition declares that the first man who had the courage to carry an umbrella in London was Jonas Hanway, a famous traveler and merchant. Strange as it seems to us, he had to brave the jeers of mocking crowds because he preferred to keep his clothes dry rather than to have them wet by the rain. Boys ran after him, taunting him with being "Frenchy," and he was ridiculed in the newspapers of the time. It was of course only ignorant, stupid, or depraved persons, old and young, that insulted him publicly. Yet it was he who founded the first free hospital for the London poor.

There are made out of wood two more articles which we should know something about. One of them is produced by burning green timber, covered to exclude the air as much as possible. The product is familiar to us all as charcoal. Forest charcoal-burners put logs together as close as they can, fill all the spaces with branches and twigs, and overspread the whole with turf, thus forming a structure somewhat like an Indian wigwam. The wood is then set on fire, and left to burn slowly. The very best charcoal, however, is made of wood burned in closed ovens, which are so constructed as to admit no air.

This latter method is troublesome and expensive, and is employed only when another product (besides the charcoal) is wanted — acetic acid, or wood vinegar. This acid has many uses. It is valuable in the kitchen; for, when diluted with seven times its weight of water, it becomes a vinegar of the most palatable kind. Acetic acid is employed as a medicine, and is used in large quantities by dyers and calico printers, and is serviceable also in certain important chemical processes.

To obtain this very strong acid, green timber is packed in iron cylinders, which are inclosed in a brick structure of which they form the floor. Under them are furnaces which heat them red-hot, and keep them in that condition for some hours. Each cylinder is fitted with a pipe that leads into a large tube, in which all the vapor produced in the different cylinders condenses, and forms a thick fluid. Of course the oven doors are fastened air-tight, — fire-clay being usually plastered over the crevices. The burning is maintained all day. In the evening the fire is permitted to subside. Next morning, when the doors are opened and the cylinders are emptied of their contents, each log will be found changed into charcoal, weighing about one-fourth of the original weight of the wood, and the large tube will contain an acrid, ill-smelling, brown liquor. This is distilled, mixed with lime, and allowed to evaporate till it crystallizes; then sulphuric acid is added, and the liquid is distilled again. This time the product is the clear, colorless, intensely sour fluid known as acetic acid.

LESSON XXXVI.

From Nature's Glass-works.

THE history of the world's famous diamonds is full of incidents and surprises. The eyes of sacred Brahmin idols have blazed with these superb stones. They have adorned the crowns of kings, and have been buried in the rubbish of pawnshops. They have mysteriously disappeared, and have been just as mysteriously returned. Often they have bred war. They have even been swallowed under murderous attack, and have afterwards been found in the bodies of the victims. These celebrated gems are six in number: the Great Mogul, the Koh-i-noor, the Regent, the Sancy, the Orloff, and the Matam.

It is no wonder that romances have been woven round these inestimable jewels. Nor is it surprising that the ancients, knowing little of chemistry, should cherish the most absurd beliefs as to the properties of the diamond. The gem could not be burned, and no force could break it — so the Romans thought. A celebrated Latin author, Pliny, wrote: "Diamonds are tested on an anvil by blows from a hammer; these blows they resist to the extent of causing sparks to fly on all sides, and the anvil is sometimes destroyed." Pliny died in the year 69 A.D., but for centuries afterwards belief in the unbreakable quality of diamonds remained in full strength.

A French chemist, Lavoisier, first proved the falsity of the assertion that the diamond cannot be destroyed by fire. Any diamond, exposed to intense heat, burns up. The experience of glaziers suffices to establish the fact that the stone wears away under constant use. A diamond employed daily in glass-cutting is worn out in six weeks. Experts in precious stones have calculated that a diamond will travel over about thirty miles of glass before becoming useless for cutting. Not every diamond will cut glass; a stone of naturally acute angles must be used.

Diamonds are of various colors — white, yellow, orange, pink, brown, green, blue, black and opalescent. The most valuable gems are pure white. Two elements determine the value of a diamond — its brilliance and its size. Suppose the gem's luster to be of the highest grade — of the first water, as jewelers say — then the size decides, in a general way, the price, this increasing in proportion to the square of the weight. A stone of two carats is worth four times as much as a stone of one carat, and a stone of three carats nine times as much. A diamond of one carat is about the size of an ordinary pea, and may be worth a hundred dollars.

Notwithstanding the antiquity of diamond wearing, the art of cutting and polishing the diamond is of modern origin. From India we learned nothing in that art. There, the diamond workers were inclined to sacrifice luster in order to retain weight; they never mastered the principle of increasing the brilliance by increasing the number of the facets. Many of the finest old India diamonds have been recut by European hands. The modern method of cutting diamonds into regular facets was invented by Van Berghem in 1456.

The stones to be cut are fastened with cement to the prepared ends of hardwood sticks. The workman, who wears leather gloves, takes a stick in each hand, and, leaning them against two upright pieces of iron fastened on the edge of his bench, rubs the two diamonds together until he has produced a flat, even surface (which is a facet) instead of the concave or convex form of the natural stone. By this process a facet is cut on each stone at the same time. The diamond dust ground off is received in a small box containing oil, and this dust is burned, before being used for polishing, in order to free it from particles of cement that may have become mixed with it.

The first process of cutting gives only eighteen facets. The afterwork which produces the other facets is called polishing; and this operation is performed by means of diamond powder on a steel disk, rotated very rapidly by steam-power. A diamond is split, if its natural form is bad. The skilled cutter knows the planes of cleavage, and works on them. With splinters of other diamonds, he grooves a line on the surface of the stone to be split; a very fine knife is then inserted in the mark made, and a quick blow with a hammer splits the gem.

The largest India diamond known is of the shape and size of half a hen's egg, and weighs

280 carats. It is estimated to be worth about $2,500,000. This diamond is called "The Great Mogul," and is now in Persia. The celebrated "Regent" diamond comes next in rank, and, though smaller, is much more brilliant. It is said to have originally weighed 426 carats, but after two years' continuous labor it was reduced to 136¾ carats, at a cost of thirty thousand dollars for the cutting. A wonderful white diamond, weighing 457 carats, was found in South Africa in 1884. It was purchased by a company of London and Paris merchants, and placed in the hands of a skillful cutter. It has been cut twice, and now weighs about 200 carats. Its owners have named it the "Star of South Africa."

Strange as it seems, the chemical element, carbon, which forms the diamond, is the same substance that forms coal, kerosene, charcoal, and burned sugar. These four very dissimilar things are made of the same material, and their carbon may have come from a strange fish or plant buried millions of years ago! Now, carbon, like nearly every other substance that exists in the solid state, will crystallize — that is, after being vaporized, it will, on cooling, assume definite geometrical forms. Chemists have often attempted to crystallize carbon, and thereby to produce diamonds. Experiments made in England, a few years ago, resulted in the production of some small crystals, which deceived the most noted diamond experts. But the process by which these artificial diamonds were obtained was so dangerous and costly as to be useless for commercial purposes.

Ordinary imitation diamonds — rhinestones — are made from "strass," a superior kind of glass, or are natural transparent crystals. These crystals are harder than the glass diamonds, but lack even moderate brilliance. In France, lately, some imitation diamonds of remarkable excellence have been put on the market. They are manufactured from flint combined with certain chemicals, the compound being kept at a high heat for many days continuously.

The value of the diamond as an ornament has been appreciated from the earliest ages, and in the East the mining of these precious stones has, from time immemorial, been a privilege of royalty.

The India mines are not only the oldest, but are also the most extensive in the world, the diamond district of the peninsula reaching from near the river Penar in the south to the river Stone in the north, a tract in the east Deccan, over seven hundred miles from north to south, and from thirty to two hundred miles in width. Some of the most productive territory is in the dominions of the Nizam of Hyderabad, and here were the long-famous mines of Golconda.

This was the name given them, but in reality Golconda is not a name of a mine, or even of a district, but of a fortress round which a town has grown up. In former days the castle was held by a strong garrison, and gems from all the surrounding country were gathered into the fortress as a place of security. Hence Golconda became a market for the mines of Central India, and a Golconda brilliant might come from any one of a hundred mines in the vicinity.

Formerly all mining was under the supervision of the Indian potentates, but diamond digging is now carried on in a desultory fashion by the natives. The India diamonds are found in localities having an upper surface composed of loam and sand, perhaps two feet in thickness, under which lies a stratum of black clay from two to four feet thick, and under this the diamond soil, — a stiff clay intermingled with large round stones.

Here is the diamond-hunter's harvest-field. The deposit is from two to three feet in thickness, and after being reached by the removal of the overlying strata, is dug out, and treated in one of two ways. When water is abundant, the mud is washed through a sieve, and the stones remaining in the sieve are examined to ascertain what gems may be among their number. When the mine is in a dry locality, the mud is removed, dried in the sun, then broken into powder, and subjected to a close scrutiny.

The utmost degree of care must be exercised in examining the soil from the diamond layer, in order that no gems may be overlooked, for a diamond the size of a pin-head is the reward of many days' labor, and its loss is not to be replaced.

The finest gems in the world are of India origin. The Koh-i-noor, the Koh-i-toor, the Regent, which once glittered in the handle of Napoleon's sword, the Orloff, for which the Empress Catherine gave four hundred and fifty thousand dollars in cash, an annuity of twenty thousand dollars, and a title of nobility, together with a large number of other noted gems, came from the Deccan diamond district of India.

Diamonds have long been mined at Pontiana, in Borneo, a locality where a search for the precious stones is still in progress, and from time to time the labors of the diggers are rewarded by the discovery of valuable gems. The most famous stone from the Borneo mines is the great gem in the possession of the Sultan of Matam. It weighs 367 carats, and is valued at $3,500,000.

In the province of Minas-Geraes, Brazil, the negro slaves had for a considerable time used as counters certain bright stones which they found in the streams. Along came a traveler, who had spent some time in India, and, recognizing the value of these stones, he purchased a large number for a few cents each, and took himself out of the country with all imaginable haste.

A year or two later a large party of well-armed men began to make mysterious researches in the province where the negroes had found the shining stones. The men were diamond-hunters, and before the government became cognizant of their work, large numbers of valuable gems had been found, and taken out of the country. When the fact became known, a stop was put to the searching, the foreigners were expelled, and the government took charge of the mines.

For a long time the Brazilian stones were regarded as inferior to diamonds from India and Borneo; but save a tinge of color, generally yellow, which is often found in the Brazilian stones, there is no reason for their supposed inferiority, and when they are white they cannot be distinguished from the brilliants of the Deccan mines.

The largest uncut diamond in the world is reputed to be the Braganza, which was discovered in 1741 in a Brazilian mine, and which remained in the possession of the crown until the abdication of Dom Pedro, when it was resigned to the republic. It is said to be the size of a goose-egg, and to weigh 1,680 carats. But the jealous privacy in which it is kept tends to confirm the popular suspicion that it is only a white topaz. If it were a genuine diamond of the first water, its value would be over $2,000,000,000.

But Brazil does not depend upon her diamond mines for wealth. During the first hundred years of diamond mining in Brazil, or from 1756 to 1856, the output of the mines was $20,000,000, and in the year last named the export of coffee alone was $28,000,000. From the port of Bahia there are every year exported $1,000,000 worth of diamonds and over $4,000,000 worth of sugar, thus proving that what grows on the earth is of more importance than what is found underneath its surface.

In 1868 the adventurers of the world were excited by reports of the discovery of diamonds in South Africa. As elsewhere, the discovery was the merest accident. A little boy playing on the banks of the Orange River found a bright stone, which he used as a plaything. Its value was not suspected, until one day a hunter, recognizing the value of the gem, purchased it for a small sum, despite the boy's remonstrances, had an examination made of it, and it proved, when cut, to be a diamond of twenty-one carats, and of great brilliance.

Search was made, with astonishing results, and at present upwards of six thousand persons are engaged in the mines along the Orange and Vaal Rivers. A remarkable feature of South African mines is the large size of the stones produced; over a hundred have been found exceeding thirty carats in weight each.

Nearly all, however, are yellow, and the effect of the South African discoveries has been to reduce the price of yellow stones to about one-fourth their former figure. The diamond diggings of South Africa cover an area of about twenty thousand square miles, the whole of which was at once claimed by Great Britain, and annexed as soon as its value was discovered. In one important respect the South African diggings are different from those of other regions, for in Africa the diamonds are found from the surface to a depth of upward of one hundred feet.

As a rule, diamond strata lie close to the surface, but in the South African mines the contrary is the case, and better gems are found from eighty to one hundred feet below the surface than are met with in the early stages of the work.

The method of working surface mines is exceedingly primitive. A claim is staked; all the earth is removed, one bucketful at a time, and carefully sifted for the diamonds it may contain. The labor is done by blacks, who, after leaving the mine, are closely searched lest they should steal the product of the day's labor.

Extreme care is necessary, for the diamond comprises so much value in so little bulk that it is quite possible for a dishonest employé, unless attentively watched, to carry away many thousand dollars' worth of gems. Every mine-owner, however, is provided with emetics, and the negro suspected of swallowing gems is promptly doctored.

In spite of the utmost precautions, however, employers are subjected to great loss on account of thefts by the laborers, and in every mining camp there are dishonest dealers, who buy from the blacks stolen diamonds at a small part of their value, and then smuggle them out of the neighborhood.

A stone may be turned up by one of the washers when the watcher's eye is elsewhere. He deftly hides the jewel in his hair, or swallows it, or forces it down the throat of a dog, a goat, or any other animal that may be handy. When opportunity offers, he rescues the gem from its hiding-place, and sells it to another native, a tout in the employ of a "mean white," as a dishonest, petty, diamond-dealer is called in the South African colonies.

The tout in his turn sells it to his employer for perhaps double what he paid, but still for only a fraction of its value, and the "mean white" finds a diamond-merchant who will ask no questions, and who will pay possibly a tithe of what the stone is worth. The last purchaser smuggles the gem out of the country.

From the South African mines have come several noted diamonds. The "Star of South Africa," a stone of about 200 carats, is, perhaps, the most perfect stone of its size in existence. The test for the purity of a diamond's color is to place it in a glass of chemically pure water, and if the gem is perfectly white it will become invisible. The "Star of South Africa" is one of the few stones which meet this test. In the last twelve years eight *tons* of diamonds have been taken from the African mines.

Several diamond fields in Australia have yielded largely, but most of the gems are inferior in color and brilliancy. Immense fortunes have been made in the Australian mines, and it is believed that there are many localities in that great but little known continent where diamonds will be found in abundance.

In the United States these precious stones have been met with in several parts of Virginia, in the mountains of Georgia and North Carolina, in one or two river beds in East Tennessee, California, Arizona, and New Mexico. At no place, however, have they been discovered in any considerable numbers, and the largest stone found within the limits of the United States weighed twenty-three carats.

LESSON XXXVII.

Molding Clay.

HERE we are at the pottery which we propose to visit to-day — a number of low buildings, no two of them connected. We have always known that tableware is made of clay, but now, for the first time, we are to see a lump of dark, wet earth turned into a beautiful china teacup.

In the yard we notice not only clay — *that* we expected to see — but also heaps of flint-stones, piles of calcined bones, tubs of lime, of feldspar, of cobalt, and of other substances intended to find their way, eventually, into crockery for our pantry shelves.

As the flints have to be reduced to powder, they are burned in a kiln until they have lost their extreme hardness. Then they are chopped into bits by a curious-looking roller, which is set with short, heavy, iron blades. Now the flint is ready for the runners. Rather slow running these must do, we think, as we survey them — huge cylinders of stone with iron axles and frames. The flint bits are shoveled into gigantic kettles in which the runners are whirled round and round with tremendous speed. Water flows on the flints while they are undergoing this grinding process, which goes steadily on till a paste is formed of flint-flour and water.

Next, for the "slip-house," to which this strange paste is carried. What is "slip"? This large vat contains the answer to our question. Dry, white clay was put into the vat, water was allowed to stream in through that pipe in the side; and then these big paddles, driven by a powerful steam-engine in the basement, beat clay and water into thin batter — slip, the potters call it.

One of the men dips out a quart canful of the slip, and weighs it. Apparently the result is satisfactory, for he gives a signal, and the noisy beating stops. A plug is pulled out of the vat, and the white batter is permitted to flow out into a cistern, passing, on the way, through immense sieves of heavy silk. When all the kinds of clay needed have been thus prepared, they are blended together in a huge box. Strips of zinc around its interior indicate the different quantities of clay creams to be poured in. When these have been thoroughly mixed together, and have been beaten by the revolving arms into foamy batter, the mixture is pumped into colossal wooden presses, very ingeniously made. Looking into one of them, we observe that it is divided, by means of iron slats, into several compartments. There is a linen cloth in each division.

Outside the press we perceive several pipes. We are informed that when the slip is considered to be properly blended and strained, it is forced into the largest pipe, and out of that into the smaller ones, each of which communicates with a compartment in the press. Flowing back into each division, the slip is caught in the outspread cloth, so that when the vat-door is opened several rolls of moist clay are ready to be carried to the workroom next in order — the pug-mill.

There the clay is cut, and chipped, and sliced by rows of knives fixed in a frame. Great care is taken to drive out all the air, in order that "blistering" shall not spoil the ware by and by. Finally the clay, having been fashioned into big slabs, is pronounced ready for the potter's use.

We want first to see the "thrower" at his work, because we have heard that making pottery is one of the few trades in which there has been but little improvement effected in hundreds of years. In the old Apocrypha it is written, —

"The potter, seated at his labor, turneth his wheel about with his feet, and maketh all his work by number.

"He shapeth the clay with his hand, and boweth down his strength before his feet."

Certainly these lines might have been penned to-day, instead of ages ago, so accurately do they describe the methods by which the thrower transforms a lump of wet clay into a figure whose beautiful curves enchant the eye. Very ancient indeed are the tools with which the potter achieves such artistic results—fingers and thumbs! Watch the ease and quickness with which he can mold the clay into a cup, or a vase, or a ball, or a plate, one thing changing into the other before we can discover how the change is produced. He appears simply to smooth the wet earth with his hands, the thumbs inside and the fingers out, the little table whirling around rapidly all the time, and—presto! one article becomes another.

When we pass on, he will return to his work for this day, the throwing (making) of small basins. He uses a few implements; a length of brass wire for cutting; a "rib," which is a sort of wooden knife, and a compass-like tool, called a callipers, used for measuring. The basins which he shapes are carried off to the "hot-room," a long, low building heated by steam-pipes. A clerk notes down in an account-book the quantity of basins, mugs, or other articles "thrown;" for the potter "maketh all his work by number." On this room's shelves are placed, to dry, the various products of the throwers.

The clerk, noticing us looking at some round articles, explains that those are mugs minus their handles, those *handy* parts being put on in the room below. We may follow that boy, he adds, if we "care to see how handle-fitting is done; he is about to carry down a load of mugs to the turners." The boy takes up a board covered with mugs, and disappears down a very wide stairway.

Following him, we find ourselves in a large, light room. Lathes are ranged around the sides, and an air of close attention to business is worn by every one of the employés here. Our boy tips his cargo of mugs onto a turner's bench, and goes back up-stairs.

The turner seizes one of the little, round, clay vessels, sets it on the chuck of his lathe, adjusts the pulley, and the mug spins around so rapidly that the eye cannot recognize its form. Holding a small brass knife, or chisel, to the mug's surface, the man shaves off long ribbons of clay. A touch on the handle of the belt-pulley, the wheel slackens its speed, coming to a stop in a minute; the mug is removed, another is fixed in the lathe, and again the clay shavings fall. All day long he repeats these operations over and over again. His labor is monotonous in the extreme, it seems to us; yet he must not stop, except at the cost of losing money; for he, too, is one of the potters who "work by number."

We notice a turner blowing some liquid by means of a kind of teapot onto a basin in his lathe. He shows us that the vessel has two spouts, and is almost full of blue "slip," quite thin. Applying one of the spouts to his lips, he gives a puff. In a moment a broad band of blue color has been laid on the outside of the basin. Substituting a mug, he changes his teapot, blows sharply, and lo! there are five narrow, blue lines around the vessel. They form perfectly true circles, and decorate the mug very prettily.

Observing that we are surprised to see that one teapot produces more lines than the other, though both are seemingly just alike, the workman explains that the spout which he used last has a metal cap with wires across it. This cap can be twisted on or off, whenever he wishes.

Narrow vases, candlesticks, bouquet-holders, — in short, all articles of odd shapes and raised patterns must be molded. The molds are made, like the ones for rubber toys, in halves. Wet clay is rolled thin, pieces of about the size required are stamped out and packed into the half-molds; these are fastened together, and the molds are put aside to give the clay time to set.

When the molds are opened, the articles will be complete, except that projecting parts — knobs, handles, and spouts — will be lacking. If we should inquire how these necessary portions are added, we should be told that they are fashioned separately, and are attached by using "slip" as a cement.

We step into the room pointed out by a molder as the one in which handles and spouts are made. Near the door we see a young man modeling handles. These are for small pitchers, he tells us. Before him is a tray full of thin clay strips, each about five inches long. Taking them up, one by one, he flattens the ends over his left thumb and front finger, forming each slip into a graceful curve. By his side we notice another worker molding spouts. His plaster-of-paris mold resembles an overgrown nose, we think; but such a fancy does not seem to run through his brain, judging from the earnest way in which he attends to his task.

Half a dozen workmen, just beyond, are engaged in making teapots. Lids, bodies, spouts, handles — all are made separately. The articles produced in this apartment are carried into the "hot-room," dried there, and returned here to be fitted, by means of slip, to the vessels to which they belong. Unlike the furniture factory, this establishment uses no glue, paste, nails, nor cement. The wonderful slip serves all the fastening needs of the potters.

Leaving the teapot-makers, we next find ourselves watching the "flat-ware" pressers. As might be expected from their name, they are busied in shaping out flat or open articles — dishes, saucers, plates, and similar objects. And how fast the workmen are making them! "How many plates do you turn off in a day?" I ask the presser nearest to me. "About sixty dozen," is his reply. Seven hundred and twenty plates in ten hours!

Here, as in the hollow-ware rooms, we see clay being rolled into thin sheets; stamping machines cut out of them disks the size, each one, of some kind of plate — dinner, tea, dessert, breakfast, fruit or other pattern. A presser lays one of these clay pancakes on his mold, which looks exactly like a stone plate reversed; his little table spins swiftly around; he holds a tool against the end of the mold for a few seconds, and the pancake has become a neatly modeled plate.

On our way across the yard to the big circular kiln, which is built of firebricks, and is bound with huge bands of iron, we are informed by the boy piloting us that all the clayware which we have seen is baked in this curious oven. Even the cheapest dish must be baked, or, as the boy says, *fired* twice.

"In this shed the men are packing plates for the next firing," says our youthful guide.

We look in, and see several workers arranging dishes in rough, shallow, round pans, made of a special kind of fireclay, and very carefully made, too, no doubt; because on their power to resist heat rests the safety of the articles placed in them. Experienced hands are needed to do this packing properly; for no dish must touch another. Two pieces of clay in contact, while being fired, would fuse together. Small, spiked, angular pegs, called spurs, are used to keep the articles apart. Lumps of flint are also put in the bottom of each pan. As hundreds of these fireclay cases have to be filled for every firing, it is little wonder that the latter operation is watched with considerable anxiety. The first firing is looked after with especial care, as it usually reveals imperfections in form or material, unnoticed till then by the workmen.

Next comes the arranging of the filled pans all round the dingy interior of the kiln. They are so placed that the flat bottom of one forms a top for another, except, of course, in the uppermost layer, and the pans containing the largest articles are put where they will obtain the most heat. When the kiln is packed full, the doors are shut and bricked up; and the fires (eight of them) are lighted. For forty hours or more the baking of this monster oven's contents is continued, an intense heat being maintained all the time.

Careful men are selected to attend to the firing process. Great vigilance is required to prevent the ware from spoiling. It may easily be baked too much or too little. The critical moment is the instant in which the doughy clay hardens into earthenware. At that moment the baking must stop, the roaring flames must be allowed to subside, and the kiln to cool.

It is quite interesting to look at the contents of the pans after the firing. How altered and improved are the dishes! The dingy, heavy, opaque clay has been transformed into crisp "biscuit," or unglazed ware; each article has grown lighter and smaller, but the shape remains unchanged. The examination of the biscuit is held in the "placing-room." There, the sharp eyes of trained workers quickly detect any flaws.

The dishes that have passed examination are, like school-children equally fortunate, promptly promoted to a higher room, where further attractions are added to them. The first one is glazing.

We can easily understand that earthenware would be of little use were it not coated with smooth, hard enamel.

Unglazed ware is rough, porous, and unpleasing in appearance. Compare a flower-pot with your best china teacup, and you will gain some idea of the advantages to be acquired by passing examination.

Following a load of biscuit, we reach the dipping-room. At the end of it is a small vat in which a mass of glaze is undergoing stirring by a bare-armed man. As soon as the ware is set down by his side, he takes up a piece, and dips it quickly in the clear, thick compound; then he whirls the piece rapidly about, while hardly touching it, apparently. Were the articles not spun around in that fashion, the sticky glaze would not spread evenly over all the surface.

Every pottery uses at least three kinds of glaze, the workman tells us: one for the cheapest kinds of earthenware, one for press-printed ware, and one for porcelain. Even the commonest glaze is a mixture of several substances, such as flint, white-lead, feldspar, and glass, all pulverized, and then made into a thin paste. When a glaze is required for chemists' vessels—vessels into which strong acid may be poured without damage to them, no lead is put in the mixture; it is then compounded of sand, potash, lime, and nitre, powdered and well stirred together. This compound is baked till it melts. Then it is permitted to cool into a hard substance. This, ground into powder, forms the basis of a beautiful, clear, liquid glaze.

Now, suppose we take a glimpse at the printing of the plates which we saw pressed in the building across the yard.

What is meant by "printing"? The process of fixing designs and colors on the ware. We all are familiar with cups and platters bedecked with blue garden-scenes, green landscapes, pink sailboats, red flowers, and other crockery-ware ornamentation.

Only a few hands are, it seems, employed in the printing-room. A man, with part of his face and all of his hands colored blue, is engaged in taking proofs of a copper-plate engraving. First, he rubs a thick, blue ink over the plate; then he lays on it a piece of strong tissue-paper, which has been slightly moistened with soapy water; putting plate and paper together in a press, he moves a lever, and an oily blue picture, or proof, is the result.

This proof must be cut and shaped to fit the plate's curved surfaces. The transferrer then smooths the paper picture on the plate, pressing the proof with a flannel roller. When the paper is removed, we see a landscape — blue trees, blue grass, blue flowers, and three blue cows! The plate will next be sent to the hardening kiln to be baked, in order to prevent the fading of the colors.

For the second firing, which is done in the glaze-kiln, all the different articles are again packed in the big earthen pans, the slight opening between pan and pan being stopped with clay. The object of this second heating being to fix the glaze on the biscuit-ware, the baking does not require half the time of the former one. The earthen cases are arranged differently, articles with the same glaze being grouped together. The printed ware is placed on the floor.

Through the open windows of yonder building, which, we notice, is quite large, though only one story in height, we catch glimpses of numbers of workmen as busy as bees. Looking in through a doorway, we are surprised to see that the entire structure is devoted solely to the manufacture of drain-pipes. These are used in great quantities for sewer-systems in cities and towns, for draining wet land, for conveying water from springs to houses, and for various other purposes. The largest pipe here in the manufactory to-day is pointed out to us. It is fifty inches in diameter, and is, therefore, big enough for several boys in our school to file through without bending their heads very low.

These tubes are made of fireclay, and are glazed inside and outside — not, indeed, by being dipped in a creamy compound of flint and chemicals, but by means of common salt. This is spread on the floor of the kiln in which the pipes are fired.

The salt, decomposed by the intense heat, falls in fluid form on the pipes, and, on cooling, it hardens into that lustrous enamel which is so valuable a feature of all this kind of stoneware. Of it not only pipes but also pans, kettles, bowls, pitchers, jugs, jars, and other vessels equally useful, are made.

In Lesson XXXII. we read that an artistic fashion of Roman times — the use of ornamental tiles in building — has lately been revived. Clay for tiles undergoes the same beating, mixing, and straining that we have already witnessed. It is also dried and pulverized. But at the grinding-room door of egress the aristocratic tile-clay and the useful, hard-working, crockery material part company. Steam and machinery are employed to dampen the clay for tiles; and then it is set aside to "ripen" for a while. Afterwards we can meet with it in the "press-room." There, squares of the clay, colored to suit prospective buyers, are placed in presses, and are rapidly stamped into neat tiles.

If ornamental tiles of the more costly kind are desired, the stamping process is varied by using brass plates, which are perforated to form a pattern. Differently colored clays are often added one on another, the design being on a color unlike the margin. All tiles go to the drying-room. After being properly dried, they are placed in the kiln, and are baked slowly. Then they are taken out, cooled, dipped in a special glaze, and once more fired in the big brick oven.

The most expensive tiles are the inlaid, plastic ones. A mold of the design is made of plaster-of-paris. This mold is set in a frame, on which a second frame of the exact size of the tile fits closely. The modeler first puts in fine clay, to form the ground-work of the pattern ; then he adds some coarser clay, which has been mixed with burned and powdered ware, this mixture being used to prevent the heat from warping or twisting the tile ; another layer of fine clay is spread on ; the frames are squeezed together, and then the tile is taken out. The hollows in it are filled up with different kinds of thick "slip" of various colors.

The tile is then laid away on a shelf in the drying-room. Next day the design will be smoothed over with a broad-bladed palette-knife, the tile will be dried again, rubbed smooth once more, and, finally, will be fired in the kiln.

It is a curious fact that the most important coloring agent used in any pottery to-day is obtained from an ore which, for hundreds of years, was regarded as worthless refuse. It seems to have first troubled the men working in the silver mines of Saxony and Bohemia; for they named it after the evil spirit that they believed to dwell in every mine, — its "kobold." The mineral is now used in making oxide of cobalt. When the silver ore was smelted, the cobalt gave off arsenical fumes that endangered the lives of the workmen tending the furnaces. As these fumes were not visible, it is little wonder that the miners, ignorant and superstitious, should consider the blue stones to be the deadly playthings of wicked, invisible spirits.

How did it happen that a profitable use was at last found for this detested cobalt? Tradition says that one day a certain Christopher Schüring, a glass-maker of Plattei, was wandering in the mining district of Bohemia, and he took notice of the great heaps of blue ore piled around the openings of the mines.

He carried home with him some lumps of this substance, new to him, and ground them into powder. This he mixed, by way of experiment, with some grit, and baked all together, no doubt querying whether he had not wasted the whole contents of the melting-pot. To his surprise and delight the result was a beautiful, deep-blue "slip," such as he had never before seen.

He utilized his discovery by manufacturing oxide of cobalt for glass-makers and potters, and he soon became rich. His thoughtful experiment changed a useless mineral into a substance of great value to various arts and industries.

Superstition dreaded the ore as a poisonous compound made by an invisible demon. Science compels this same ore to minister to our sense of the beautiful. The thoughtfulness which may bring value out of waste can be cultivated by every one of us. The field of industrial art, whereon we may win wealth and fame, is wider than ever to-day. But we must constantly bear in mind the Scriptural warning that no man liveth to himself alone. Whatever work we choose, let us try to serve not only ourselves but others also.

LESSON XXXVIII.

The Oyster's Jewel.

IN most countries of the East, and particularly in Persia, the pearl was held in the highest esteem. The ancient Mexicans were in nowise behind the Orientals in appreciation of this gem.

The palace of Montezuma, Emperor of Mexico, at the time of the Spanish invasion (1521), was studded with pearls and emeralds; and several other Aztec monarchs possessed pearls of extraordinary size, which were got, it is supposed, from the pearl-fisheries of Panama.

The ancients do not seem to have had any clear idea of the natural process by which the pearl is produced. The Romans thought that the gem was made of dew that fell into the shell of a kind of mussel! But the origin of the pearl is not quite so romantic. The gem is simply carbonate of lime that has been secreted by the pearl-oyster from sea-water. This lime compound is, however, mixed with some fluid peculiar to the fish. The pearl's shimmering gleam is caused partly by the exceeding thinness of each of the layers of the gem's substance.

In the center of every pearl there will be found some foreign matter, usually a tiny grain of sand. The bivalve protects itself against the irritating effects of the intruded object by enclosing it with successive folds of the substance out of which the lining of the shell is made. The fish thus turns the cause of its discomfort into a thing of beauty.

Many elevating thoughts have been suggested by this marvelous fact. The finest sentiment is, perhaps, to be found in the precept of the distinguished German writer, Jean Paul: "Let every affliction and disappointment be to thy character a means of refining and perfecting it; remember that the oyster, when injured, closes its wound with a pearl."

To induce the bivalve to secrete the pearl-forming substance, no end of ingenuity has been shown in introducing particles of various materials within the shell. The Chinese have outstripped all other peoples in the successful practice of this curious art. Minute tin-foil images of Chinese gods and animals are put in the open shells of mussels found on certain parts of the China coast. After a time these images become coated with mother-of-pearl. They are then withdrawn, and find ready sale, some of them being of considerable value.

But though much has been made clear regarding the circumstances of pearl production, there are points still unsettled. The bivalves abound, but they do not produce pearls in all localities. The most reasonable explanation is that the chemical constituents of the water have much influence in pearl-forming, and of course these constituents vary greatly not only in different waters, but even in the same water at different times.

A foot and a mantle are characteristics of the pearl-producing mollusks. The common snail can show us a foot like that of the pearl mussel, and the clam can boast of that covering of flesh known as a mantle. The mussel uses its foot, not for walking, but for sticking to its home. This mollusk spins long, silky threads, throwing them out with its foot, and attaching them so firmly to some rock that the waves do not sweep off the fish.

These delicate cords can be readily dropped by the mussel, which can also refasten itself without difficulty. Singular as it may seem, the threads are sometimes cleaned, washed, dried, mixed with silk, and spun into a beautiful brown material, fit for gloves, caps, and other articles of clothing.

Various methods have been adopted to win pearls from the deep. One of the earliest Arab geographers, writing in the ninth century, describes the contrivances of the pearl-divers of his day. They filled their ears with cotton, soaked in oil, and pressed together their nostrils with tortoise-shell clasps, before plunging into the water. The pearl-fishers of the Persian Gulf employ the same precautions even at the present time.

Off the coast of Ceylon, the diver inserts his foot in a harness made of leather straps wound about a sinking-stone, and inhales a full breath. Leaping into the water, he sinks rapidly to the bottom. As soon as this is reached, the stone is drawn up; and the diver, having thrown himself on his face, fills his basket with mussels as rapidly as possible. At a pull on a cord attached to a belt around his waist, he is hauled up by men in a boat. A capable diver can remain under water, at work, for sixty seconds.

It was long thought impossible to produce pearls by entirely artificial means, but in 1680 a Paris jeweler filled hollow glass beads with the ground scales of a small river fish (the bleak), and since then the world has easily obtained imitation pearls.

No city in the world was ever richer in pearls than was Rome in the time of the Cæsars. Historians make special mention of the extraordinary quantity of these gems owned by Lollia, the wife of the Emperor Caligula. On occasions of state, she used to appear so bedecked with strings and rows of pearls that she shone like the sun, when she moved.

Take the shell of a pearl oyster and remove by grinding or with acid the rougher coat. What have you left? A sheet of perhaps an eighth of an inch in thickness of pure pearl, the precise substance which the bivalve deposits around any foreign body, like a grain of sand that gets under its mantle, thus producing the pearls of commerce. Why not take this sheet of nacre, dissolve it in acid, and then redeposit the pearl in layers about a buckshot suspended in the solution, thus imitating as nearly as possible the method of nature?

If it were practicable to make pearls at all in this way, perfect ones could be formed every time, of any shape desired. There would be no difficulty in turning them out as big as base-balls. But the fact is that the concretions thus obtained would be mere lumps of carbonate of lime, lacking entirely the iridescence which in the pearl is due to structure.

The structure of the pearl shell is a study in itself. Its outer coat is a sort of skin of lime, very hard and dense in texture, designed to protect the animal from the action of carbonic acid in the water. Beneath this skin is a coat that the microscope proves is composed of a multitude of little prisms stood on end side by side.

On the under side of the layer of prisms is the pearly substance itself, which is deposited in sheets so thin that seven hundred and fifty of them are required to make an inch in thickness. These sheets slant at an angle toward the surface, so that their edges, with their wavy parallel lines, interrupt the light that strikes them, and thus produce the beautiful iridescent effect.

Not long ago it was found out that by scratching parallel and wavy lines across a piece of glass, say a thousand lines in an inch, an effect precisely similar was obtained, and artificial pearl buttons have actually been made lately without using pearl at all, steel being the material employed. Lines were cut across the steel surface very close together by machines, thus giving to it the same brilliant sheen of rainbow hues as is exhibited by the finest mother-of-pearl.

Of course the material was much cheaper, but unfortunately buttons made of it were found to tarnish almost immediately and to lose their beauty, so that their manufacture has been abandoned.

The most valuable product of the pearl fisheries of the world to-day is not the pearls themselves, but the shells from which they are obtained, which are used to the extent of many millions of dollars' worth annually. Various other nacreous shells, including the famous nautilus, are turned similarly to account. The first process is to remove the outer coat.

The workman holds the shell against an emery wheel until all the rough part is ground away, leaving merely a sheet of mother-of-pearl. The thin shell is then placed in contact with a revolving brush which smooths it, and the final polish is given with rouge. Next the shell is cut up into pieces of the desired shape and size by means of a small circular saw.

So skillfully is this work performed and with so little waste of the pearl that a shell from which buttons have been thus turned out is left but a skeleton, with mere threads of its substance remaining between the round holes. Even this residue is not thrown away, but it is ground up and mixed with a paste of rubber or other substance for molding into buttons of the sort which show bright speckles of pearl in them.

The most beautiful mother-of-pearl, unless that of the abalone be excepted, is obtained from the nautilus. Its dwelling is composed of a series of empty chambers, each of which the animal has successively lived in, and vacated as it grew bigger, building up behind it at each move a wall of pure pearl.

These vacant rooms of pearl are all connected by a pneumatic tube, which enables the creature to control the air supply in its house so effectually as to make the domicile lighter or heavier at will, in order to ascend or descend in the water. The shell is too thin to bear grinding, and muriatic acid is used to remove the outer coat and to disclose the exquisite nacre beneath.

A method of treating such shells consists in drawing on them, with a brush dipped in varnish, any design desired; they are then placed in a bath of weak acid. This liquid eats away the outer coat wherever it is not protected by the varnish, the result being a lovely cameo with raised figures in white on a pearly ground.

In the cretaceous epoch, hundreds of thousands of years ago, there lived certain cephalopods, which science calls "ammonites." The pearl they produced was of wonderful beauty, and many fossil ammonites dug up to-day have been so operated upon by the processes of decay as to form elaborate patterns in pearl and white on the shells.

No artificial work can compare with the rainbow-hued richness of these relics of the past — reminders of that strange age when oysters and other mollusks had a more important place in creation than they now possess.

Apparently nature does not make pearl for decorative purposes, else it would not always be on the inside of shells, and hidden beneath an ugly coat of lime. The object for which it is intended is evidently to afford a smooth and comfortable dwelling for the soft animal within. The color of the nacreous deposit varies very much. Thus pearls themselves are white, black, blue, purple, pink, and even green.

It is estimated that no less than $200,000 worth of abalone shells are shipped from the Pacific coast annually, the wholesale price being from $500 to $700 a ton. The "haliotis splendens," as it is called by conchologists, is gathered chiefly by Chinamen, who detach the animals from the shore at ebb tide, when they adhere to the cliffs near water mark with their single shells slightly lifted.

The end of a pole shod with iron is thrust quickly beneath the "foot" of the creature, so as to destroy the suction, whereupon the abalone falls off, and is captured before it can re-attach itself. Otherwise it might be smashed to pieces before it could be torn from the rock. Now and then a lone Chinaman gets his hand caught by one of these animals, and is held prisoner until he dies. Clams of the common sort yield pearls sometimes of good size, but they look so much like common pearl buttons as to be worthless.

Occasionally pearls are found of such curious and fantastic shapes as to represent, with the addition of a little gold or enamel, heads of animals and other objects suitable for scarfpins and other ornaments. A pearl was sold at a large price not long ago which strikingly resembled the head of Michael Angelo. The pearl-forming mollusk has an interesting way of using its nacre for protection against the boring worms and sponges which attack it.

To keep these borers out the animal spreads coat after coat of pearl over the spot where the hole threatens to come through, thickening the walls on the inside as fast as it is eaten away from the outside, just as a man might mend the roof of his house from within. Because the nacre which makes pearls must be subtracted from the material which would otherwise go to make the shell, oysters which contain pearls are usually deformed.

Frequently a pearl that seems opaque and, therefore, of no value, is found to be lustrous and beautiful upon removing the outer layer with a weak solution of acid, or upon peeling it off with a knife. A pearl is rounded by the mollusk revolving it continually.

The finest pearls of the world come from the Persian Gulf, where the oyster beds produce $2,000,000 worth per annum.

It is here also that the finest pearl shells are found, some of them measuring a yard across when opened. The pearl fisheries of Ceylon belong to England, the natives being employed to gather them on a basis of shares in the result. All sorts of superstitions prevail among them and a large business is done by swindlers who sell charms to restrain the appetite of the sharks and to drive away the stingrays!

Another peril which the diver dreads more than either stingray or shark is the giant clam, which weighs nearly half a ton when full grown. It will snap off a man's arm like a pipestem if the victim chances to thrust the limb between its open jaws, or, at all events, will hold him until he drowns miserably. The average diver thinks it a fair day's work to secure 100 pearl oysters in 50 feet of water. After being taken ashore, the mollusks are allowed to die, when their shells open of their own accord. The pearls are classified by passing them through a series of sieves, which assort them into different sizes.

It is only in the Gulf of California that regular diving-gear is employed in connection with the pearl fishery. The beds there were pretty nearly destroyed a hundred and fifty years ago, when from 300 to 500 pounds of pearls were taken from them yearly by the Spaniards. The pearls were packed in baskets, and sold by the bushel!

The most beautiful pearl in existence is "La Pellegrini," at present exhibited in a museum at Moscow. It is perfectly spherical, and so brilliant and pure as to appear almost transparent. Weight, 90 grains. The imperial crown of Austria contains a pearl of 300 carats, but the biggest one in the world is the "Hope Pearl," now in London, which weighs six ounces and measures two inches in length, its estimated value being £60,000.

There is a pearl in the Spanish regalia weighing 400 carats. It was obtained from the Gulf of California. Green pearls come from the Marianne archipelago. Two big ruby-red pearls were found at the Ceylon fishery ten years ago, and are owned by the rajah of the Sulu Islands.

The story of Cleopatra's dissolving of a great pearl in vinegar and drinking the mixture must be set down as mythical. It would take a very long time for vinegar to dissolve a big pearl, and any acid strong enough to dissolve it quickly could not be drunk.

Unlike most gems, the pearl comes to us pure and lustrous, nature's own handiwork. Other precious stones sometimes owe much of their beauty to art. But the pearl is in no manner indebted to man. It is a gift of nature absolutely. The pearl is a child of light. Kept in darkness, it loses its luster. Perhaps this fact will suggest to some bright boy or girl the reason why the Old Testament calls the pearl the symbol of wisdom.

LESSON XXXIX.

Martyrs of Invention.

IN Europe, one hundred years ago, it was a perilous undertaking to bring out a new invention designed for use in any bread-winning occupation. The man who could perform a mechanical feat which was beyond the ability of his neighbors was regarded as a dangerous person. Industrial life has had many a martyr. The success of each new machine has depended so much on the profit it yielded to the world that the man who thought out the machine's principle and plan has too often been neglected in the confusion of the final triumph.

It is in connection with the machinery used to produce textiles that inventors have met with the greatest ingratitude. The very working people whom they were seeking to benefit proved to be their worst enemies. Capitalists have often been ready to welcome improved methods of making goods.

But the laboring classes were against inventors in the critical period when the change from hand work to machine work was effected. It was stupidly believed that the more extensively machinery was employed, the less demand would there be for hands. The working men and women could not be made to understand that the great quantity of fabrics, which would be produced by steam-driven machines, would lower very much the prices of those fabrics; and the decreased cost of goods would result in a vastly increased use of them: hence, as more textiles would be called for, more people must be employed to tend the machines. It was the hatred of the operatives that made the lives of the early heroes of the factory so full of dangers and difficulties.

To the popular mind the introduction of machinery meant enriching the mill-owners and starving their employés. Savage rioting was the reply of the masses to every plea for the need of better modes of manufacturing. Time and experience have proved to the working classes that their dread of machinery was groundless.

Wages are much higher than they were in the last century, and employment is more easily obtained. The general condition of the country also has been decidedly bettered. Operatives are more educated and intelligent now than they were a hundred years ago. They comprehend their own interests more clearly, and inventors have no longer to contend against mobs. The working-man does not nowadays consider the mechanical genius his mortal enemy.

The inventor of the flying shuttle, John Kay, was born in England in the first half of the eighteenth century. Brought up to his father's trade, weaving, he grew impatient at the clumsy manner in which his looms worked. The woolen handloom of his day was, in truth, an unwieldy piece of apparatus. It had not been improved for probably four thousand years. In plan and principle it was the same awkward implement that had supplied Egypt with mummy cloth. He invented a machine whose chief feature was the famous flying-shuttle. His loom enabled the weaver to produce twice as much cloth, to improve the quality, and to do the required work far more easily.

Viewing these benefits in the light of our present knowledge, we find it hard to understand why Kay should have been persecuted to the brink of the grave by the very persons he was trying to serve. He started a small woolen mill, and it was destroyed by the populace. He set up another mill at a great cloth center, Leeds. The manufacturers united to defraud him out of the royalties due him on his patent shuttle.

He returned to his native place, and sought for help among his old friends, but the wild prejudice against his invaluable invention followed him wherever he went. Hardly was he settled at home when a mob tore down his house, and would have killed him had not two of his relatives managed to convey him in disguise to a place of safety. Several times he petitioned the English government to grant him some reward for the great service which he had rendered the textile industries, — a service that was felt in the remotest bounds of England's trade and commerce, — but his petitions were dismissed with contempt. He died in France, in extreme poverty, attended by only a faithful daughter.

Hargreaves, who, in 1767, devised the spinning-jenny, was hardly less unfortunate. His invention was suggested by the sight of a bobbin revolving on an old-fashioned spinning-wheel, which had been accidentally upset, while in operation. Yet, doubtless, thousands of other young men had been witnesses to similar overturns of spinning-wheels, without thereby being led to reflect that, if one bobbin could be made to rotate, to wind up thread, while in a horizontal position, perhaps a row of eight or ten bobbins could be placed parallel to the floor, and be operated by machinery.

Such were, however, the reflections that passed through young Hargreaves's mind, and, after numerous failures, he at last constructed a piece of apparatus that successfully ran eight bobbins.

The increase of spindles made possible by his machine filled the spinners of his parish with anger and alarm. To escape their violence, he fled from his home, in Blackburn, to Nottingham. Here, severe distress overtook him, and he sold his rights in the machine. "Necessity never made a good bargain," is one of the sayings of Poor Richard, a name under which one of the wisest of Americans, Benjamin Franklin, wrote to instruct the laboring classes of his day. Kay got but a small sum for his great invention, but the purchasers reaped a colossal fortune from their bargain.

Crompton, the inventor of the spinning-mule, might well be ranked among the greatest benefactors of mankind. His rewards, however, were persecution, hatred, slander, disappointment, and poverty. Till the mule was devised, no yarn, satisfactory to the weavers, had been produced by machinery. Crompton was a poor boy, working for his daily bread at a loom in his mother's humble cottage.

Like every other weaver of his day, he was annoyed by the constant breaking of the yarn. He was obliged to stop his loom many times an hour to piece together the broken threads; and, finally, he determined to invent a spinning machine that would make better yarn. To overcome the various difficulties that presented themselves, he worked at his invention far into the night, resuming in the morning his labor for the means of living. Seeking no aid from any one, he continued his experiments for five years. At the end of that time (1779) he had perfected a machine that worked successfully. It produced a yarn of fineness till then utterly unknown in Europe.

As soon as that fact became noised abroad his house was beset with persons eager to rob him of the product of his brain, and his life was turned into a long misery. All kinds of devices were tried to gain admission into his little weaving-room; even ladders were placed against its windows for the use of spies. He could not leave the house for fear of having his discovery stolen from him. His shy nature prevented him from profiting by his invention, and, from lack of funds, he could not get it patented. Every penny he owned had been spent in its construction.

A manufacturer persuaded him to disclose the secret to the cotton-cloth trade by promising him a liberal subscription, but all he ever received was the paltry sum of £60. Mill-owners made gigantic fortunes out of the machine. Crompton died broken-hearted. From the day on which he gave up his invention to the public, his life was an agony of bitterness and disappointment.

A young French weaver, Joseph Jacquard, was at one period of his life in such straits that he was forced to sell his loom, and to become a laborer in a lime-kiln. In 1802 his attention was called to a newspaper paragraph stating that the English Society of Arts would pay a reward for the invention of a machine that could weave fishing-nets. He soon devised such a machine, and a friend took it to Paris, where it came under the notice of the Minister of War, the famous

Carnot. He sent for Jacquard, and commissioned him to make another netting loom.

One day while Jacquard was at work, with his sleeves rolled up, the door of his shop flew open, a dozen military officials in gorgeous uniform marched in, and formed in two lines. Down the center came the most powerful ruler in Europe, the great Napoleon, then the autocrat of France.

"Well, Master Jacquard," said he, "what progress have you made with the loom that is to weave nets for our hardy fisher-folk of Normandy?"

"Sire, it is completed."

"But this is not the machine?"

"No, Sire; this is a loom that will weave figured or brocaded silks. It will save the poor weavers the bodily torture that they now suffer all day long. All who work at the trade become deformed in a few years, owing to the strained position made necessary by the use of hand-brocade looms."

Jacquard's labor-saving machine amply fulfilled his promises. It proved to be one of the few inventions which seem to have been thought out perfect on first projection. Yet the very weavers that Jacquard endeavored to rescue from lives of pain rose in wild rage, when they heard of the new loom, tore into pieces the one specimen he had finished, and made desperate efforts to kill the maker! Jacquard himself afterwards said, "The wood of the loom was sold for wood, the iron for iron, and I, the inventor, was held up to public insult."

Let us now trace the history of another invention, one that has saved innumerable lives, and has rendered it possible to mark out ocean routes on charts as accurately as railroad lines are drawn on maps.

One of the most brilliant triumphs of applied science is the method by which the navigator finds at sea his vessel's exact position on the globe. There may be nothing, except water and sky, within his view; he may be in mid-ocean or be gradually nearing land; but if he has a correct chronometer, and can make an astronomical observation, he can readily tell how far he is from home as well as from his intended port. He is able to drop grappling-irons at a designated spot, which may be three thousand miles from land, and to pick up a telegraph cable for repair. This remarkable feat of scientific navigation would be impossible were it not for the invention of the marine chronometer, — a big watch that will keep perfect time in any climate.

The chronometer was the outcome of a crying need of navigators in the sixteenth century. They wanted some method devised that would enable them to steer with certainty across the pathless ocean. Spain was then the chief naval power; she was the most potent monarchy on land also, and she held half America under her sway. One of her monarchs, Philip III., offered a reward of three hundred thousand crowns for the discovery of any mode of correctly ascertaining a vessel's position at sea. This rich prize was left unclaimed. Spain had no skilled mechanicians.

Holland became a great commercial nation, and her king ordered the sum of thirty thousand florins to be presented to the man who should satisfy this need of the mariners. Some efforts to obtain this reward were made; but they failed, principally through the inability of the artificers of those days to make accurate astronomical instruments.

England succeeded Holland in mercantile power. When Charles II. founded the Greenwich Observatory, it was understood that Flamsteed, the astronomer-royal, should devote his energies to finding some method of determining longitude by observations of the heavenly bodies. A degree of progress in this important work was made by eminent scientists of the time. Halley and Newton gave their attention to the subject, but again full success was prevented by want of efficient instruments.

In 1714 the English Parliament enacted that twenty thousand pounds should be awarded to the discoverer of the means of finding a vessel's position within thirty geographical miles. This splendid prize was open to all the world. Experiments were made for many years, but the construction of an accurate marine time-keeper seemed to be as illusive a project as ever.

At length, to the surprise of every one, the great problem was solved by a village carpenter named John Harrison. His grand invention was first known as the compensation clock. Before it was presented to the world, a ship at sea, out of sight of land, was, in a measure, lost. There was no method known for finding out her location. She might be hundreds of miles out of her course for aught her captain knew. Often it was the appalling roar of breakers on a rock-bound shore that first told the hapless navigator that he had made a fatal mistake in his reckoning.

When Harrison began his great work in 1728, he had to face a thousand obstacles which never trouble clock-makers of to-day. The perfect tools and the beautiful machinery seen in American clock factories were then unknown. Harrison had to make his tools; he had to learn how to work in brass and iron, and he was still obliged to earn his living by drudging from morning till night at the carpenter's trade.

In 1735 he completed his first instrument, and carried it to London. It was given a trial on board a war vessel, going from London to Lisbon. The motion of a ship at sea would, it was known, destroy the time-keeping properties of any clock of those days. On meeting Harrison the commander of the war-ship said, "A clock that could do all you claim for yours is an impossibility."

He spoke as the world always speaks of new inventions. The first steam-engine, the first sewing-machine, the first locomotive, the first steamboat, the first telegraph, the first telephone, every other great discovery in science and art — all were impossibilities!

The machine — the first chronometer was four feet square — kept time remarkably well, and proved its value in a striking manner on the return voyage. On sighting land, the ship's course, as regulated by the captain, was shown by the instrument to be ninety miles out of the way. Harrison had fairly won the prize; yet, for the twelve years following, he was denied even a hearing by the commissioners who had been appointed to examine the claims of inventors, and to grant the twenty thousand pounds to the one whose timepiece should fulfill the conditions imposed by Parliament.

Plunged in the deepest poverty, Harrison nevertheless managed to make two more chronometers, the third one being smaller and more accurate than either of the others. Finally, the admiralty, the navy department of England, again ordered him to submit his invention to another trial. He was to take his best instrument on board a naval vessel, the Deptford, and to allow his clock to be tested on a voyage to Port Royal, Jamaica.

Again, the chronometer showed its extraordinary usefulness. The Deptford reached her destination three days before an equally fast sailer, the Beacon, though the latter ship left Bristol ten days before the former. The Beacon, having no accurate guide, had lost her way. Thirteen days had been saved by the big watch! It proved, when returned to London, to be only two minutes behind star time. Again its inventor was put off with frivolous excuses, when he applied for the money long due to him. His son was directed, in 1764, to go with Harrison's latest chronometer, a fourth one, to Barbadoes, on board a man-of-war. This last instrument erred still less than the third one, and was smaller also.

The commissioners meanly refused to pay the long-suffering inventor more than a small portion of the reward which he had richly earned. He might have died of starvation, had not the King of Sardinia ordered of him four chronometers at one thousand pounds apiece. His Majesty declared that his purchase was made "as some slight recompense for the time spent by Mr. Harrison in advancing the general welfare of mankind."

Harrison was now old and feeble. He had constructed four chronometers, any one of them sufficiently accurate to be entitled to the reward of which he had been so long and so unjustly deprived. It was not until 1773, or thirty-eight years after he had accomplished all that Parliament required him to do, that he obtained the sum which the nation had owed him for over a third of a century.

It is worthy of notice that the peculiar glory of inventing the chronometer was reserved for a humble mechanic who, by constant effort, surmounted all obstacles. His tireless industry succeeded where mere learning had failed. He did not, indeed, attain his aim without the exercise of great mechanical skill; but all his inborn ability would have been useless had he not possessed the virtues of patience and perseverance. His life is an inspiring example of difficulties triumphantly overcome, of unwavering courage in realizing a noble ideal, and of prolonged labor finally repaid with undying fame.

LESSON XL.

Secrets of Dyes.

How many great discoveries in the arts and sciences have been due to accident! And inventions destined to change industries, to enrich nations, to shift centers of trade, to bring distant countries into close relations, have also had their origins in chance.

One morning, centuries ago, a botanist was wandering along the shore of the Ægean Sea. His attention being attracted to a strange weed, he plucked it, and placed it, still wet with dew, in a book he had with him. Some days afterwards, on removing the plant, he saw that it had left a blue impress of itself on the leaves. The secret of that valuable dye, indigo, was thus revealed to the world of the Middle Ages.

The beautiful, bright-green weed which the scientist thoughtfully preserved in his book is remarkable from the view-point of botany. Five petals compose the blossom, each one so distinctively shaped as to require a separate name. The top one is the largest, and is called the Flag. The two leaves just below are termed the Wings;

the lowest petal is the Boat, and is composed of two hollow flower-leaves, which hold the seed portions of the plant, and shelter them from rain.

The indigo plant belongs to the Butterfly order, botanically speaking. All butterfly plants have the curious habit of spreading out their wings in the day-time and folding them together at night.

Linnæus, the prince of botanists, ascertained this fact in the following way. A butterfly-plant's seeds were sowed in his greenhouse, and these soon produced two beautiful flowers. The botanist, wishing to show them to a friend, went with him, at night, to the box wherein they were growing. No flowers were visible. They must have been broken off by accident was the conclusion that the gentlemen reached.

Great was Linnæus's astonishment, however, next morning at finding his blossoms on the plant. In the evening he again took his friend to admire them, and again they could not be found! Finding them once more the following morning, looking as fresh as ever, his gardener said, "These cannot be the same flowers." Linnæus, being a scientist, was not satisfied with such an explanation. Revisiting the plant that night, he lifted the leaves, one by one, and at last he discovered the flowers completely hidden under the wings. After observing many other plants of the same order, he drew from their behavior his theory of the Sleep of Plants.

The botanist who plucked the indigo plant made a natural mistake in supposing himself to be the first discoverer of its dyeing powers. White linen robes bordered with indigo blue were garments to be found in nearly every ancient Egyptian home. We should have seen them by thousands, if we had taken a walk —

> "In Thebes's streets, three thousand years ago,
> When the Memnonium was in all its glory."

The blue-striped cere-cloths of several Egyptian mummies have been examined by chemists, and their science has proved beyond question that indigo furnished the basis of the blue coloring.

It seems, then, that the Egyptians of antiquity were well acquainted with the dyer's art. Indeed, it has been practiced among all eastern nations from time immemorial. In the Old Testament we read of the purple-dyed vestments of the high-priests, and of linen cloths dyed blue, purple, and scarlet.

The famous Tyrian purple, obtained from a species of shell-fish (the *murex*) was discovered by a shepherd about 1500 B.C. His dog bit a murex; and he noticed that the animal's mouth became stained a beautiful purple. Later on, Tyrian purple was adopted as a badge of royalty, and cloth colored with this shell-fish dye commanded a royal price. The dyeing industry gave wealth and prosperity to Tyre and Sidon more than 1200 years B.C.

It is probable, however, that dyeing was not a common art, judging from the distinction which colored raiment conferred on its wearers. In ancient Greece and in Rome, dyers grew more numerous. Among the ruins of Pompeii there has been discovered a dyer's workshop with all its apparatus. Gradually the ability to dye textiles well has become more and more widespread, as civilization has advanced. In earlier times dyeing was a domestic occupation, and even to-day, in some outlying portions of Europe, the colors imparted to home-made fabrics are still, to some extent, obtained from native vegetable dye-stuffs.

Among the Romans the chief article of dress was the toga, a long loose robe. It had a brilliant red border for official personages, but others wore the garment entirely white, it being woven of unbleached wool. The craft of dyers was in Rome a privileged corporation; and, in the days of the Empire, only one trade society possessed the right of dyeing purple vesture for the Emperor. The Romans, as they advanced in power and wealth, clothed themselves in richly colored costumes, the ladies, especially, arraying themselves in apparel which had been dyed in the most splendid manner.

After the fall of the Roman Empire, the art of dyeing was lost to Europe for several centuries; it was brought there again from the East. The gloomy skies of England were not suggestive of bright colors, and, as commerce had perished for the time being, dye-stuffs were not imported. Europe produced a few dyeing substances, however, which had been used for ages. The two principal ones were woad and madder. Cæsar mentions woad as a weed employed by the Britons to color their faces blue, in order, probably, to render their appearance more terrible to their enemies.

The wisest monarch of the Middle Ages, Charlemagne, ordered that madder should be cultivated on his farms, and that it, with other dye-stuffs, should be supplied to the weaving-schools which he had founded, so that dyeing also might be taught. Records that have come down to us prove that the wearing of garments solid-colored, checked, and striped had begun to spread.

Flanders was early celebrated for scarlet cloth of fine quality. The delivery of a thousand ells of it, sufficient, it was said, to clothe a hundred knights, was one of the conditions on which Count Henry of Schwerin, in 1225, granted the release of King Waldemar of Denmark from captivity. Scarlet cloth formed an important part of the load of presents that Henry the Lion, on his crusade, sent to the Greek Emperor.

An order of dyers was instituted in Venice in 1439, and the art of dyeing had then so far advanced that the dyers in black regarded the dyers in red as rivals. The crusaders, returning to their homes, brought back with them the taste for gay colors. The unskilled dyers of Europe could not, however, imitate the beautiful designs of the Arabs. For many years cloths dyed in solid colors were the only ones for sale at prices bringing them within the means of the poorer classes.

Bright colors were considered the finest. In the first half of the fourteenth century, red clothing lined with yellow was a fashion affected, on holidays, by the Genoese. The citizens of Bologna wore, as marks of culture, scarlet robes lined with green. Refinement of taste was so little cultivated that gentlemen wore jackets having one sleeve colored red and the other yellow! Clothes dyed to resemble a checker-board were common. Similar bad taste was often displayed in embroidering: one side of a garment would be richly worked and the other one would be left plain.

Nevertheless, the colors were lasting; and the weaving and the embroidering were very skillfully done. Many of the robes and tapestries preserved from mediæval times are of fine texture, and their colors are as bright as if the textiles had been dyed yesterday. It should not be forgotten, though, that only the wealthy could procure a handsome garment.

The production of cloth was limited, because spinning and weaving were done by hand, and the benefits of steam-driven machinery, of spinning-mules, power looms, shearing machines, and all the other iron workers in the cloth-factories of to-day were yet to be thought out by geniuses of industrial life — men to whom we all are deeply in debt. They are the ones whom we should honor more than we honor conquerors or statesmen. The heroes who have subdued the mighty forces of nature, compelling them to satisfy our needs and wants — those men are the greatest benefactors of mankind; they are the heroes to whom statues should be erected, and whose birthdays should be observed as holidays.

At this time gaudiness in colors was the rule among the rich; the poor had to struggle hard to obtain even the coarsest textures of dark colors. Gradually the taste of the wealthy classes improved, and before the close of the fifteenth century children were the only wearers of variegated attire. It was during the Middle Ages that black was adopted for mourning color, a custom still followed.

Prior to the discovery of America the dye-stuffs used in Europe were comparatively few in number, although added to from time to time by the progress of knowledge. Long before this hemisphere was seen by Columbus, brazil-wood was known to Europeans; and the Spaniards, meeting with forests of a similar tree in South America, gave the name Brazil to a large portion of that grand division.

This wood, together with sanders-wood, was employed for dyeing red. Yellow dyes were extracted from saffron, fustic, and safflower. But the principal dyeing substance, for many centuries, was indigo. It is still used, though not to any such extent as in the past. Its name indicates the country from which it came — India. There, it is still cultivated. Once sowed in a loose, rich soil, the plant requires no care till harvest time. In the Northern provinces of Hindustan parties of natives may be noticed, in July, clipping off the bright-green leaves and twigs of the indigo plants.

Gleaners pick up the portions cut off, bind them in bundles, and load these on carts, which convey them to the mills.

In every mill there is an immense vat. This is filled with the leaves and twigs, and water is poured on them. Fermentation soon begins. At the end of sixteen hours all the vegetable material is decomposed, and the water — which has turned quite green — is allowed to run into another building, in which is located the "beating-vat." A score of Hindus, with arms and faces dyed as blue as any blue cambric ever made, whip the liquid, with long rods, for several hours. The green water turns blue from contact with the oxygen in the air. You remember that the dark blood in our bodies, on becoming aerated by the lungs, turns red.

The sediment in the blue liquid is permitted to sink to the bottom of the vat, and the water is drawn off. The soft substance left is boiled and skimmed, and then is shoveled into gigantic sieves. Through these the water drains away slowly, leaving the indigo, which now suggests beautiful, blue cream-cheese.

Cochineal is a red dye-stuff composed of insects, which feed on the nopal cactus, a plant very abundant in the lowlands of Mexico. This dye was formerly believed to be a berry. Even years after travelers had carried back to their European homes true accounts of the real nature of cochineal, many dyers refused to believe that it was of animal origin. They were unable to detect the usual marks of insect structure. Cochineal is, however, an insect having six legs, a very minute head, and no wings.

The insects feed on the sap of the nopal. They are brushed off, and are killed by being thrown into hot ovens. Cochineal is a very rich coloring material. It produces, besides red, various tints and shades of pink, scarlet, and crimson. Experiment has proved that it requires seventy thousand of these strange little insects to make a pound of dye-stuff.

Madder is a vegetal product which grows in many parts of the world. Turkey cultivates the plant quite extensively. Like most of the other vegetable color-plants, madder would appear to be now of little value. It has served its day and generation ; the cheapness and the brilliance of the coal-tar dyes have driven it nearly out of the market.

Logwood has been an important factor in the dyeing industry. This dye-stuff is a tree, flourishing chiefly in Mexico and in the adjacent portions of Central America. Reaching here in large pieces, it is rasped by machinery into small fragments, suitable for the extraction of the coloring matter. It is employed to produce dark colors, such as black, chocolate, and brown.

The third foundation color of dyers, yellow, has had for its bases fustic and quercitron bark. This bark is the inner sheathing of a species of black oak, a native of tropical America.

The art of modern dyeing is the creation of chemistry. This science has a noble history, and there is no enterprise in which its services have been enlisted in vain.

Chemistry is ever hard at work. It is filtering water, detecting in it, oftentimes, the germs of fatal diseases, which might have been carried into thousands of homes. It is making artificial ice in the most sweltering summer days. It is ever finding new uses for so-called waste, but it never achieved a more signal triumph than when it discovered the most splendid dyes in that forbidding dross, coal tar.

A young assistant in the laboratory of the Royal Institution, in London, was one day trying to make artificial quinine out of one of the coal-tar products. The substance that fell to the bottom of his test-tube was a deposit of some chemical that he had never before seen. A prophetic flash indicated some secret of Nature then and there revealed. He washed the deposit; he melted it, and the beautiful color, mauve, was for the first time revealed to mortal eyes! His discovery was better than the unearthing of a gold mine — it was a key that, in dyer's hands, opened other men's gold mines. It was a liquid purple, perfectly transparent, and it had been reduced from coal-tar! The young man patented his process, erected dye-works, with borrowed money, and in a few years he accumulated a large fortune.

In former times a man that stumbled on the secret of a new tint or shade was obliged to keep the discovery secret, if he desired to reap the benefit of his good fortune. In the Middle Ages dyers were few, and they formed themselves into guilds. Every member of a guild took an oath never to divulge the methods of his craft. From the fall of the Roman Empire to the thirteenth century the Jews held most of the secrets of the dyeing art. A traveler, known as Benjamin of Tudela, who visited Jerusalem about the year 1165, says that he found not more than two hundred Jews living there, and most of them were engaged in the dyeing of wool.

Coal-tar is composed of several different substances. The material furnishing mauve is termed *aniline.* Hundreds of patents have been taken out for methods of making artificial coloring matters from this coal product. A French chemist treated aniline with chloride of tin, and thus obtained the fine color which has become so well known under the name of magenta. Violet, purple, olive, maroon, and blue dyes were rapidly evolved from this same mineral source. Indeed, the color-creating powers of coal-tar are, seemingly, endless.

Hundreds of other tints and shades have been obtained from this refuse of the gasworks. To-day the dyer holds a prominent place in the industrial world, and society owes him a debt of deep gratitude for the wonderful change he has wrought in the aspect of all textiles. The variety and the surpassing beauty of the colors seen in modern cloths have never been equaled. A domestic servant can now afford to buy a purple dress more brilliant in hue than was any robe ever worn by the wife of a Roman emperor.

Allied to dyeing is cloth-printing, or the art of impressing colored figures or patterns on woven tissues, an industry more recent than that of printing on paper. Perhaps Augsburg, Germany, must be credited with the honor of being the first city in Europe in which the art was practiced.

In the beginning the process was tedious and clumsy. It was conducted by means of blocks on which the patterns were cut, as printing on paper is now done in China. Different colors were applied by successive impressions. The rolling-press (invented in 1783), by means of which any length of cloth, passing under an engraved roller, is printed in a few minutes, was a tremendous stride in advance of the old hand-work operation.

Much ingenuity has been exhibited in constructing improved forms of this press. The latest one prints six colors at one turn of the rolls. These cylinders are colored while revolving. Most striking is the fact that they can be engraved in a few minutes with any pattern. Galvanism is the engraver — a worker of rare force and quickness.

The art of designing attractive patterns for textiles is taught in school in many cities in Europe. Paris, the leader of fashion in the civilized world, was the first city to establish a school in which drawing designs for woven fabrics formed part of the course of instruction. Germany has now numerous schools of design, and her embroidery work is, therefore, sought for eagerly by purchasers of all nations.

The proof of chemistry's power, given in discovering the coal-tar dyes, has been rendered still more impressive by the lessened cost of the new coloring materials. The name *alizarin* had been given by chemists to the dye-element in madder. This very same substance was found in the waste from gasworks — coal-tar. There is apparently no difference between the alizarin obtained from the vegetable, madder, and that obtained from the mineral, coal.

The artificial alizarin well illustrates the economy introduced by science into the industrial arts. The greatest textile-manufacturing nation, Great Britain, consumes every year about 7,000 tons of alizarin, the value being nearly $2,500,000. The same quantity of madder would cost $15,000,000! And the application of all the new mineral dyes is so simple that it seems doubtful whether the older dyes will be continued in use much longer.

Assuming that a piece of textile has been subjected to the cleansing and whitening process known as bleaching, the next step is to consider the nature of the fibers. If these are of animal production, as silk and wool, the fabric can be dyed by a simple immersion in a bath containing the color; but color so applied to a vegetable material, as cotton, can be easily washed away.

The fiber in the latter case requires some special preparation to make the dye adhere; and a *mordant* is employed for that purpose. Mordants are usually mineral or metallic salts. These salts are applied to the yarn or cloth; and, when the textile is immersed in the coloring liquid, they unite with the color substance, and form with it, in the fibers, a compound that cannot be washed out.

Single textures can now, at one dip, be dyed several brilliant patterns and colors; peculiar shades can be produced; the most diverse fabrics can be dyed together, and the colors will remain fast. The mordants most largely used are the salts of alumina, iron and tin. But no mordant is needed by the coal-tar dyes. As they are, therefore, more rapid in application and more economical in cost than the vegetable coloring materials, we need not be surprised to learn that Europe uses annually $20,000,000 worth of these brilliant mineral dyes, which, we must remember, are gifts of modern science.

LESSON XLI.

Labor and Progress.

THE study of the industrial arts is important, not only because it teaches us how very gradually mankind has become able to utilize what Nature has provided, but also because it helps us to see that every art is the outcome of mental toil. The inventions and the discoveries which have lightened labor, increased the means of living, and enlarged the sphere of opportunity for each and every one of us are results of ages of experiment.

It is true, indeed, that in this century progress in all the industries has been made by leaps and bounds. Our grandfathers had no better means for producing a spark of light than the use of flint and steel, the same method that the Romans employed two thousand years before. During that long interval of time the science of chemistry had not been developed far enough to suggest a better method for striking a light.

In 1833 phosphorus matches were introduced. Phosphorus was no new discovery, for it had been obtained in the eighth century by an Arabian scientist named Bechil, who separated it from decaying bones. It was, however, forgotten soon, there being in his time no printing-press to perpetuate the feats of science, but was rediscovered, in 1669, by Brandt, a German chemist.

But before phosphorus could be used for lucifer matches, several other chemical discoveries had to be made. The substances which must be added to it, in order to make it ignite quickly, remained unknown till 1833. The first lucifers were so poisonous to the makers and so injurious to the lungs of the users that the match-trade was not of much importance, commercially, for several years.

In 1845 another German chemist, Schrötter, found out how to change the dangerous, waxy phosphorus into the harmless red kind. Minor improvements have been adopted from time to time, until finally we have the parlor match of to-day.

Now, what have all these various discoveries in this small manufacture done for the nation, so far as regards economy of time? The United States burns up daily eight matches for every individual in the population. To supply each person's eightfold demand for a light, fifteen minutes at least would be exacted by the tinder-box of our grandfathers. An ordinary match will furnish an available light in three seconds. Thus, each match-user is saved, by these discoveries of chemistry, on the average, over eighty-five hours a year! This is a curious instance of the manner in which science leads to economy of time and, therefore, of wealth, for time is money.

This illustration of the extremely rapid progress made in rendering matches safe, convenient, and cheap, when science was called to the aid of the lucifer manufacturer, may serve to show us that mere manual labor — labor that is simply routine work, is little better than raw material, and is of but slight value in the industrial arts. It is by mental labor that human beings have become civilized — that they have risen from a state of helpless dependence on the wild fruits of the season and the scanty spoils of the chase to a condition of settled society in which every bodily need can be satisfied.

The first craftsmen began work where the required raw materials were most easy of access. As wants increased, trades multiplied, and centers of production soon arose in localities having special advantages.

What has been the deadliest foe of progress in all industries? Ignorance. Were all persons well educated, we all should enjoy more of the comforts of life. Ignorant populations make no advances in science. Uneducated mechanics cannot earn as good wages as their educated fellow-workers receive.

Suppose a man entirely unfamiliar with even the simplest forms of machinery should contract to transport a mass of marble, weighing 1,000 pounds, from the quarry to the stone-cutter's shop. To drag such a block along the rough quarry floor would require a force equal to 758 pounds. The ignorant contractor would be obliged to employ and to pay several helpers, or he could never move such a block an inch. If he knew that by laying a floor of smooth planks a force of only 652 pounds would be needed, he could save the expense of one assistant.

By placing the stone on a platform of wood, and soaping the surfaces of floor and platform, where they would come in contact, he would reduce the needed force to 182 pounds. By using wooden rollers the stone could be drawn with a force of 22 pounds. Steam-engines and rails would bring the amount of force down to 4 pounds! Thus, by the exercise of the intellect the force needed to move the block of stone is decreased two hundred times. Moreover, the workman is raised from the position of mere drudge to that of driver of a steam-engine, his wages rising in proportion.

Again, we may note the difference between the trained mind and the uneducated by considering the skill of a bricklayer and the unskilled labor required of his helper. The helper may, indeed, be called on to make mortar, a proceeding demanding some degree of knowledge, but inasmuch as he works by "rule of thumb," or by no rule at all, his occupation is not classed among the mechanic arts. The bricklayer builds by measurement chiefly, and errors in his labor can be checked by level, plumb, or square.

Does the bricklayer know whether or not his instruments are correctly made? No artisan can tell, so far as his trade skill is concerned, whether or not a rule is the precise length stated on it, or whether a square is constructed at a right angle or not. These points are determined by workers in a higher rank of labor — men learned in that branch of science called Physics. Strange as it reads, a physicist can tell whether a foot-rule is too long or too short, if he can get a chance to compare it with the pendulum of a clock beating seconds of time at the level of the sea.

Mankind had made great advances in mathematics, in painting, in sculpture, and in other branches of mental effort, centuries before the great mechanical discoveries and inventions, which benefit the world so much, were brought to light.

The question has often been asked by reflective minds, why this strange inverting of what would appear to be the natural order of progress? Why, for instance, should men have learned any course of the stars before the method of making a wagon-wheel was found out? Why did the Romans build many a colossal aqueduct before a saw-mill was framed? How did it happen that the ancient Greeks produced masterpieces in almost every department of literature before any one invented movable types?

Society has now advanced far enough to teach us the answer to these questions. Till modern times the labor of the world has been performed by uneducated men, by classes doomed to ignorance from generation to generation. The mechanics of ancient times came from the lowest order of the population. They were the bondmen of the Jews, the helots of Sparta, the captives of Roman warfare, and the serfs and slaves of modern times.

When philosophy in Athens was at its height, Western Europe was inhabited by half-savage tribes, whose only dress was the skins of wild beasts. Even in the thirteenth century slave-marts were held in various cities of Europe. As serfdom and slavery have disappeared, and as education is everywhere engaged in conquering ignorance, let us hope that science and the arts will never more be separated. We know, now, that all advances in our every-day occupations depend on the progress of science. And, as the greatest poet of our own time sings —

"Science moves but slowly, slowly, creeping on from point to
point."

The ancient Greeks knew that an empty cup turned downwards in water does not of itself become full of water; and their explanation of this fact was that the air in the cup resisted the water. Till the beginning of the sixteenth century people believed that air could be transformed into water; in the middle of that century they understood that air could *not* be changed into water, the discovery having been made that the air contains water in the form of vapor.

In 1630 it was observed that air has weight; and in 1643 that the atmosphere presses with its whole weight on all bodies on the earth's surface.

It was discovered in 1647 that the invisible particles of the air are elastic, thus explaining why the lower strata of the atmosphere are denser than the upper ones.

The physicists ascertained, in 1660, that artificial kinds of air could be produced. These are called gases to-day. Till 1727 it was not known that such kinds of air exist in plants, in animal tissues, and in rocks. About the same time it was noticed that the artificial varieties of air could be divided into two classes : one class would support combustion ; the other would extinguish fire.

In 1775 it was found out that the atmosphere is a mixture of two kinds of air : one kind being combustible, the other not. At the end of the eighteenth century physicists learned that common air contains carbonic acid. In the first half of this century ammonia and nitric acid were discovered in the air, and now we are informed by the microscope that spores and germs, by the thousand, float in every cubic inch of the atmosphere. The observations of hundreds of thoughtful men have had to be compared before we could acquire this knowledge. Yet air is the most vital of our daily needs.

The remains of old Greek and Roman civilization were preserved during the Middle Ages, by the Eastern Roman Empire and by the Arabs.

At the close of the fifteenth century improvements had been effected in the arts of mining, smelting, weaving, tanning, and glass-making.

Among the inventions made prior to this period might be named those of paper, telescopes, firearms, watches, table-forks, horse-shoes, bells, and chimneys. Better methods of drawing wire, and of manufacturing steel, had been thought out; glass mirrors had been backed with an amalgam of quicksilver and tin; wind-mills and saw-mills had been built.

Necessity, it is commonly said, is the mother of invention; it is also said that every invention is the child of its time. An invention is the outcome of a want felt by a number of persons. There is usually an urgent need of some new means to meet some necessity constantly growing more pressing. A striking example is the chronometer, an invention that, as we have read, was imperatively demanded by commerce in the sixteenth century.

How would you test the value of an invention? All inventions are ranked according to their usefulness to society. If they satisfy human wants, they are esteemed; if otherwise, they are neglected. We must remember, though, that it would be unfair to judge an invention of ten or twenty centuries ago by the standard of to-day. When the arts were in their infancy, the designing of the simplest tool was of equal importance with many an invention of greater value brought out in a more cultivated age. He who first lightened human toil by utilizing some animal's strength produced a greater change than he who constructed the first steam-engine. The first rudely fashioned pick for breaking the soil and the first fish-bone shaped as a needle may be graded with the steam-plow and the sewing-machine.

Inventions and discoveries are often spoken of as the results of accident. Even in the cases in which discovery seems to have been aided by chance, close inquiry will prove that previous education had rendered the discoverer able to seize what chance offered to him. If the observer fails to understand the meaning of what he sees, or does not grasp his opportunity, the discovery is put off till a competent mind appears. Both invention and discovery depend on a knowledge of natural laws. The greatest inventions are like the finest ears of corn: these are not found by the wayside, but are selected from the best-tilled fields, where nothing has been neglected that would render the yield superior.

During this century, in consequence of the general diffusion of education, the advance of invention has been exceedingly rapid. Every branch of industrial labor has had its methods improved, its drudgery diminished, and the cost of its products decreased.

The second half of the nineteenth century justly claims to have outstripped the first in the rate of industrial gain. Applied science is now running its swiftest race. The effect of modern inventive energy is seen in an abundance, without parallel, of the necessaries, comforts, and luxuries of life. Better opportunities for mental improvement are open to everybody. It is not too much to say that men possessing abilities that would have made them famous in ancient days now abound in every grade of society. What then must be the genius of those men who in our day are called great!

Progress has been made both in improving old methods of production and in inventing new ones. Fresh sources of raw materials have been discovered. The inventors of our time have lessened the cost of making goods, and, thereby, have brought within the range of the masses many comforts which wealthy people found it difficult to procure a generation ago.

How have these good results been attained? We know that the demand for raw materials has increased their value greatly, while the wages of the worker have doubled in the last half century.

Now, the cost of producing an article, a desk, for instance, is made up of the price of the raw materials, the wood and the metal, and the wages of the workman, the desk-maker. But, as we have said, both raw materials and wages are higher, and yet desks have become cheaper!

The aid of that modern magician, the inventor, explains the puzzle. He constructs a machine to do the work of a hundred carpenters and metal-workers. Then it becomes at once plain that the cost of wood and iron may be raised, and higher wages may be paid to the machine-tenders, while an ample profit will be left to the producer. Schools that need desks will also be benefited by lowered prices.

Furthermore, the inventor assists his kind by relieving labor of its drudgery. Contrast, for example, men yoked together to drag a heavy stone roller over a street covered with broken stone, and engineers in charge of steam-machines doing similar work! Every step upward, from mere bodily drudgery to the most highly skilled labor, is a rise in the scale of being, and brings the worker nearer to his true place in creation. The nobility of labor cannot fail to be enhanced by every gain made by man in subduing nature's tremendous forces to his will.

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